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KOREA

ELECTRONICS TECHNOLOGY PROJECT

February 27, 1979

Industrial Projects Department

CURRENCY EQUIVALENTS

US$1	=	Won 485
Won 1	=	US$0.00206

WEIGHTS AND MEASURES

All weights and measures are in metric units.

1 square meter (sq. m.)	=	10.76 square feet
1 kilometer (km)	=	0.62 miles

PRINCIPAL ABBREVIATIONS AND ACRONYMS

For technical abbreviations please see Annex 1

EPB	Economic Planning Board
FIC	Fine Instruments Center
ICE	Integrated Circuit Engineering Corporation
KAIS	Korea Advanced Institute of Science
KIET	Korea Institute of Electronics Technology
KIST	Korea Institute of Science and Technology
MCI	Ministry of Commerce and Industry
MOC	Ministry of Communication
MOST	Ministry of Science and Technology
UNDP	United Nations Development Programme

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Industrial Projects Department
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KOREA

ELECTRONICS TECHNOLOGY PROJECT

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A4. Electronics Industry Planning Study, A. D. Little Inc., June 1976
A5. Korea Electronics Industry Data Book, Fine Instruments Center (FIC), Korea, 1977
A6. Electronics Industry in Korea, Ministry of Commerce and Industry and FIC, 1977, 1978
A7. Status - A Report on the Integrated Circuit Industry (worldwide), Integrated Circuit Engineering (ICE) Corp. (US), 1977, 1978, mid-1978 update
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I. INTRODUCTION

1.01 The Government of the Republic of Korea has requested Bank assistance to finance a project that would promote and assist the technological development of the Korean electronics industry. The project has two components: (i) the development of the Korea Institute of Electronics Technology (KIET) which was established in late 1976, and which, through its service, development and production activities, would stimulate and support the electronics industry's drive into new areas; and (ii) the establishment of a Research, Development and Engineering (RD&E) program to promote and finance RD&E carried out at KIET for the electronics industry. The total cost of the project is estimated at US$63 million equivalent, of which US$33 million is in foreign exchange. The proposed Bank loan of US$29 million would finance about 87% of the foreign exchange component of the project.

1.02 Korea has sustained a remarkable record of economic growth since the early 60s; aggregate real GNP has risen at the rate of 10% p.a. over the last 15 years. This growth, based primarily on the expansion of manufacturing activity, has been spearheaded by the remarkable increase in manufactured exports. Within manufacturing, the Korean electronics industry has served as a leading growth sector since the 70s; between 1970-78 electronics production and exports rose at an average annual rate of about 50% from a low base, and in 1977, electronics products represented 11% of Korea's total merchandise exports. The industry's performance, like that for other manufacturing subsectors, has largely been based on Korea's labor advantage. Electronics export activity has consisted primarily of the labor-intensive assembly of components, and the production of technologically fairly mature, low cost consumer products.

1.03 However, recent domestic and international developments necessitate a reconsideration of Korea's pattern of comparative advantage in both the manufacturing sector in general and the electronics industry in particular. The recent rise in protectionism in the industrial countries and the rapid increase in wage rates in Korea dictate a shift away from traditional labor-intensive lines of production into areas which are more in line with Korea's emerging comparative advantage, i.e. product areas which rely on the more intensive utilization of Korea's existing and potential endowments of skilled labor and trained engineers at costs which are still low in comparison to industrial countries. In Korea's manufacturing sector, this has dictated a structural shift towards chemicals, metals, machinery and electronics. Within electronics, Korea's emerging comparative advantage is thus also perceived to lie in more skill-intensive segments of the product spectrum. The need to change the product structure has acquired a certain urgency in view of the large share of electronics in Korea's total exports, the Fourth (1977-81) Five Year Plan's emphasis on the industry's continuing role in the country's growth strategy 1/, and rapid ongoing technological changes in the electronics industry, particularly the mounting importance of semiconductors

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1/ By 1981, production is planned to increase from US$1.8 billion in 1977 to around US$4.7 billion, and exports from US$1 billion to US$3.0 billion, the latter constituting around one-fifth of total exports in 1981.

and digital systems 1/. These more advanced technologies, which have become the cornerstone of the world electronics industry, are fast replacing conventional labor-intensive assembly operations, on which Korea's electronics growth has been based, by integrated circuits (ICs) 2/; at present, these circuits constitute only a negligible proportion of Korea's production and exports. Thus, there is the need for a significant increase in Korean industry's technological capabilities in order to accelerate development into the semiconductor and digital systems areas, if Korea is to gain rather than lose export opportunities in electronics.

1.04 Chapter II presents an overview of the recent developments in the world electronics industry and discusses their implications for Korea. The world electronics industry is undergoing rapid change. At the low technology end of the industry are the relatively low skill, assembly operations and consumer products, in which Korea is becoming increasingly less competitive. At the opposite end are the research and high technology-intensive areas, such as large computers, complex mini and microcomputers, and advanced telecommunication systems. In these lies the largest potential for growth and it is here that the developed countries are increasingly focussing their scarce highly skilled manpower and financial resources. This shift by developed countries to advance into the most advanced technology area is, however, creating an opportunity for developing countries to move into the intermediate technology areas where the developed countries have already progressed down the learning curve and further cost reductions are only possible by transferring operations to countries where wages for skilled labor and engineers are still comparatively low. These intermediate technologies span areas such as low and medium-complexity semiconductors and simple microprocessor applications. Korea, like other developing countries, with the required manpower base, can participate in this emerging international division of labor, and leading world electronics companies are actively exploring the possibility of establishing joint ventures in these intermediate technology areas in Korea. For effective entry into this field, however, Korea will require substantial capabilities in the semiconductor and systems technologies, as well as resources that are well beyond those available to individual private or joint venture efforts. As has been the case in most countries, the Korean Government, therefore, plans to stimulate, support, and complement industry's effort to advance in these selected areas. The proposed project represents the lead effort in this endeavor.

1.05 The first component of the project -- the development of KIET -- provides specialized infrastructure and sophisticated and capital-intensive production services which, while they cannot be provided economically by each individual firm, are necessary for industry's development. KIET's facilities will also be used to train Korean engineers and facilitate the

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1/ A technical glossary is attached as Annex 1.

2/ ICs combine in one small "chip", (3mm x 3mm), the functions performed by up to thousands of discrete components, for which only a few years ago, several hundred times more space at vastly higher cost was necessary.

acquisition and transfer of the intermediate electronics technologies to Korea. The second component of the project -- the RD&E program -- aims to encourage technological development in the industry, wherein the rapid pace of technological change makes RD&E vital to competiveness while at the same time increasing significantly the costs and risks associated with RD&E. The RD&E program consists of selected subprojects for which KIET will share with private industry these high costs (and thus risks) and subsequent benefits of RD&E. The program will be linked directly to industry's needs and will focus on a small number of basic semiconductor and digital systems technologies and product groups where Korea can utilize its advantage with respect to low cost engineering and skilled labor resources to compete effectively in the world market. The program will aim at upgrading a significant segment of the electronics industry, and will particularly encourage cooperative RD&E efforts among Korean firms.

1.06 KIET will be equipped with facilities to enable it to undertake production-oriented development. This is expected to significantly reduce the lead time and cost associated with the transfer of research results to commercial scale industrial production, and to assist industry beyond the initial development stage by enabling it to more effectively acquire and transfer manufacturing know-how. This structure will thus combine in KIET both RD&E capabilities and production services. In addition, it is intended to make KIET financially self-sustaining in about four years after start of operations, by using revenues from services rendered to industry to gradually balance the expected deficits from its RD&E program. The project to be undertaken by KIET is designed to increase the local production of semiconductors and digital systems from around US$20 million in 1977 to about US$250-300 million (excluding potential export opportunities) by 1982, and to technologically upgrade a number of electronics products already manufactured in Korea.

1.07 The Bank has played an important role in shaping the proposed project, and its continued involvement during project implementation is expected to contribute positively to project success. The industrial sector mission of November 1974 recommended that Korea should seriously consider acquisition of the semiconductor technology as a basis for development of its electronics industry. The mission also suggested that the cooperation of Government, industry and research institutions was vital for the achievement of this objective. Subsequently in 1975-76, the Bank acted as executing agency for a UNDP-financed Planning Assistance Project which included a review of the prospects of the electronics industry and suggestions for policy formulation in this sector over the period of the 1977-81 Five Year Plan; the Plan emphasizes industry's new development thrust in the direction of the semiconductor and digital systems areas. A project preparation mission visited Korea in July 1977 to review the project proposed by the Government to develop KIET, and recommended that KIET should be redirected from a relatively isolated research institution to a service-cum-RD&E organization catering to and working directly with industry. From February to December 1978, the Bank acted as executing agency for a UNDP project to assist KIET in reformulating

and preparing the project along these lines. The project has been prepared in conjunction with industry representatives, who are keenly aware of the necessity of the services and RD&E to be undertaken by KIET, and have expressed strong support for the project.

1.08 The Bank's involvement in the project has been useful in a number of ways. The Korean Government has recognized the importance of supporting technological development in the industry, and perceives the Bank as providing useful feedback in the process of formulating strategies to encourage the accelerated development of technological capabilities in the sector. KIET's formulation as a service - cum - RD&E institution with close links to industry and its associated financially self-sustaining nature is further expected to serve as a model for other research institutions planned in Korea. The Bank will continue to play a useful role, particularly in the early years of operation of the project. The Bank's involvement is expected to help maintain "focus" in KIET's activities, a focus which is required both for the selection of appropriate products and technologies for Korea, and to prevent a situation arising where resources are spread too thin to provide an important impact on industry. The Bank's inputs are expected to contribute significantly to ensuring KIET's service-cum - RD&E orientation and its responsiveness to industry requirements. The Bank will also encourage policies for widespread diffusion of project benefits, particularly to small and medium companies, and policies for cooperation among Korean firms. And, finally, through its involvement in the project, the Bank expects to increase its knowledge of the field and its impact in industry overall, and thus become able to advise other countries which may endeavor to embark on a similar effort.

1.09 The project was appraised in November 1978 by Messrs. M. Iskander, A. Sood and S. Greig (Industrial Projects Department), and Mr. G. Madland and I. Yaakov (Consultants).

II. THE KOREAN ELECTRONICS INDUSTRY

A. Introduction

2.01 The electronics industry worldwide is undergoing a revolutionary change in technology and structure. The following sections present an overview of its recent development and prospects, followed by an analysis of the structure, performance and development plans of the Korean electronics industry. The chapter concludes with a discussion of Korea's strategy in developing the semiconductor and digital systems industries which have become the centerpiece of the modern electronics industry.

B. Background: An Overview of the World Electronics Industry

2.02 There is rapidly growing evidence that electronics is destined for a place of particular importance in the world economic system. The expanding capability of electronics to perform needed functions at attractive prices is creating an industry which is not only important in its own right but, perhaps of more consequence, is becoming a critical element in other industries. Examples of this indirect impact on large, established industries are not hard to find. The projected improvements in the automotive industry, such as in safety, gasoline mileage, and pollution controls, will be directly dependent upon the application of electronics. Timekeeping is rapidly converting to electronics and the calculator industry has almost completely moved from electro-mechanical machines to electronic ones. Computers are rapidly being introduced into factories, offices and homes in a variety of guises.

2.03 These improvements -- and those which are still to come, and which even for a few years ahead are hard to grasp in all their dimensions -- are the result of the expanding range of functions which can be performed electronically and the rapid reduction of the cost of performing those functions. Cost reductions, which are most fundamental, are, if anything, accelerating. This is likely to further expand the market for electronics into one of the most important industries in the world as shown in the following table.

World Electronics Production
(Current US$ Billions)

1965	1970	1975	1977	1980	1985
	Actual			Estimate	
38	58	84	108	150	230

Source: Integrated Circuits Engineering Corp., (ICE) of the US

The above data is shown in current terms. However, even after allowing for inflation, which has in the past and is expected to continue to balance the effects of unit price reductions, it suggests volume growth of 9-10% a year, far in excess of most other products. To put these figures into proper perspective, the present annual world steel production of about 700 million tons can be valued at about US$230 billion. This remarkable growth will create vast employment opportunities in the electronics industry, but the employment impact in user segments, such as manufacturing, has been a long standing concern. Overall, the effect of electronics -- now widely acknowledged to quickly become the dominant technology of the future -- on employment generation appears to be positive. Among others, a recent study by the industry department of the National Economic Development Council (UK) concludes that more jobs will be created than lost if a competitive electronics industry is developed. The increased employment is expected to be accompanied by a shift from low to higher skilled jobs.

2.04 For a better understanding of the following overview of the world's semiconductor and digital systems industries, it is useful to understand the variety of terminologies used to categorize electronics markets 1/: (i) Systems/Components: a straightforward division between the end product which performs a desired function and the parts which are used to build the end product; (ii) Industrial/Consumer: terms which are used to distinguish between the activities of the end user. The industrial category generally includes computers and telecommunication systems other than those specifically directed to the consumer (i.e. non-industrial) market; (iii) Digital/Linear: a division based upon the technique by which the electronics system processes information. A digital system handles information using binary arithmetic equivalents of input quantities while a linear system, in general, handles the signals directly using electrical analogs of input quantities. Digital systems include computers and computer-based applications; audio-and video-systems are examples of linear systems; and (iv) Hardware/Software: computing systems are comprised of assemblages of components, the physical system or "hardware", and the programs, or "software"; software provides instructions to the hardware for the operations to be performed by it.

1. The World Semiconductor Industry

2.05 The prime mover in the broadening of electronic capability and the reduction of electronic function cost has been the semiconductor industry. Semiconductors are solid state devices (i.e. a single crystal with no distinct separable parts) that perform certain electrical functions. They can either be discrete electronic devices such as transistors, or integrated circuits (ICs) consisting of a number of devices on a silicon chip.

2.06 The manufacture of semiconductors involves a series of highly sophisticated batch processes carried out in an ultra-clean and vibration-free environment. The first step is to melt and refine silicon into a single crystal form. The crystal is cut into wafers, typically 75-100 mm in diameter and 0.25-0.30 mm thick. The wafers are lapped and polished to a mirror finish. The desired circuit is designed, generally with the aid of a computer, and a series of masks ("photographic" masters replicating the desired circuit pattern) are prepared. Impurities are then introduced over selected parts of the wafer (to impart desired electrical properties in those parts) through "openings" in the masks in a number of steps (involving etching, diffusion, and ion implantation) to produce the desired circuit properties. A 75 mm (3") wafer costing about US$40-50 contains around 400 ICs each on a 3 mm by 3 mm chip. After the wafers are fabricated, the ICs are individually tested, and cut into single chips, each containing the required circuit. Yield, or the number of functioning ICs produced versus the maximum number possible, is the most important factor in the economics of IC production. A major part of IC technology is related to understanding and improving production yields. Expected process yields vary between 2-80% depending upon design complexity, wafer size, and the process used.

1/ See also Annex 1, Glossary of technical terms.

2.07 IC production is based on a number of process technologies belonging primarily to two families -- bipolar and Metal-Oxide-Silicon (MOS). Dominant in these families are the linear bipolar technology and N-channel MOS (NMOS) technology. Linear bipolar technology, which gave IC production its start in the 1960s, continues to be the major technology applied to production of linear ICs for consumer applications such as radios and televisions (TVs). NMOS technology developed in the 70s in response to the needs of digital applications has rapidly made inroads into other technologies and is expected to continue to dominate IC production for digital applications such as computing. The linear bipolar technology presently accounts for over 20% of worldwide IC consumption, NMOS, for over 25%, and a large number of specialized technologies for the remainder (55%).

2.08 The chief contribution of the semiconductor industry has come from progress in ICs, which have become the major electronic component. The circuit complexity has risen from a few devices per chip, to as many as 10,000 devices per chip now, as the industry moved through Small Scale Integration (SSI), Medium Scale Integration (MSI), Large Scale Integration (LSI), and now to Very Large Scale Integration (VLSI). The growth of IC production in the world is illustrated in the following table.

World Semiconductor Production
(Current US$ Millions)

Products	1973	1976	1977	1978 a/	% Annual Growth 1973-78
ICs					
USA	1,705	2,747	3,397	3,990	19
Eastern Europe	132	257	349	432	27
Western Europe	161	274	333	399	20
Asia	327	714	903	1,111	29
Others	32	38	44	50	8
Worldwide IC	2,357	4,030	5,026	5,982	21
Discretes					
USA	1,152	833	988	942	(4)
Others	1,721	1,719	1,901	2,067	2
Worldwide Discretes	2,873	2,552	2,889	3,009	-
Total	5,230	6,582	7,915	8,991	11

a/ Estimates.

Source: ICE (US).

As shown, discrete devices, although they have been the foundation of the semiconductor industry, are declining in importance due to displacement by ICs. Since prices of ICs have fallen rapidly relative to those of the discretes, the dollar figures, in fact, understate the magnitude of this shift to ICs.

2.09 A few years ago, the pace of IC technology was losing some of its momentum. While at that time, the complexity of the IC chip was growing fast, the range of functions a single type could perform was still limited. The answer was to build a standard chip with stored programs in memory so that the customers could have a choice of uses; so was born the microprocessor. Complete mini and microcomputers can now be based on the microprocessor. The IC industry is far from reaching the ultimate limitation of its technology. For 1980, the industry's target is 1 million devices on a chip (100-fold increase in number of devices on a chip as compared to 10,000s of devices at present), and the speed of microprocessors will undoubtedly rapidly increase. The fantastic growth in complexity and speed per dollar foretells many new types of home and industrial applications; e.g., computers, word processing, games, educational devices, production and process controls and a host of new ideas which have yet to be created. The long-term growth in demand for ICs worldwide is expected to be around 20% per year.

2. The World Digital Systems Industry

2.10 Another segment that has contributed to the remarkable growth of electronics, and is expected to continue to increase rapidly, is the digital systems industry (largely included in the industrial electronics segment). It primarily includes computers and related equipment (hardware), and supporting software. Digital systems are also increasingly being applied to other industrial and consumer equipment such as machine and process controls and TVs. In parallel with semiconductor developments, the industry has moved through successive generations of vacuum-tube, transistor, IC and LSI technologies.

2.11 The digital systems market is primarily categorized into (i) computer systems: large computers (mainframes), medium and small sized general purpose computers, minicomputers, microprocessor based microcomputers; (ii) special systems, such as for banking, offices, and point-of-sale systems; (iii) add-on peripheral components, such as terminals; and (iv) software services. The consumption of hardware in the world's major markets is shown in the following table.

Sales of Computer and Related Equipment
in the US, Western Europe, and Japan
(Current US$ Billions)

	1976	1977	1978 a/
Computer Systems	12.8	14.7	18.4
Special Systems	7.1	8.0	8.4
Add-on Peripherals	7.6	8.8	10.1
Total	27.5	31.5	36.9

a/ Estimate.

Source: Industry Journals.

Computer systems are the fastest growing area spurred by the introduction of micro- and mini-computers. The software market (not included above) is estimated to have amounted to around US$2.5 billion in the US alone in 1977.

2.12 The requirements for success and future prospects in the above markets differ markedly by segment; for the purpose of the following discussion, special systems are included with the type of computer on which they are based. The mainframe market, as discussed briefly below, is dominated by IBM (US) and shared by other large manufacturers in Japan and Europe. It is dependent on vendor capabilities to provide entire systems, leasing alternatives, and excellent software support and maintenance services. It is expected to grow at an annual rate of 8-10%. The medium and small computer market is similarly determined by equipment reliability and customer support requiring a broad network of support services. Though relatively small manufacturers have been able to enter this field, over 50% of market share is held by the giant mainframe manufacturers, such as IBM. Future annual growth of this market is estimated at 25%. In these markets, the lack of a track-record and reputation and the requirements for a broad service network present effective barriers to new entrants. The minicomputer market, where basic systems range between US$15-150,000, is price-competitive. Further, marketing requirements are less intense than those for the larger computers as the primary customers (original equipment manufacturers of machine tools, control systems, communication systems or small and medium computers) represent a relatively narrow market. Minicomputer demand growth is expected to average 20-25% annually. The micro-computer market derives its base from a wide range of applications, with an expected increasing reliance on consumer goods. It is expected to grow, from its present small base, at over 50% per year to reach a level of US$1.5 billion by 1982. This market provides easy entry to semiconductor manufacturers as evidenced by the entry of several US semiconductor firms such as Texas Instruments, Intel and National Semiconductor.

2.13 The add-on peripheral market is fragmented and includes a number of small manufacturers who compete with the computer manufacturers, such as IBM, on the basis of special features and price. Finally, the software/services market is fragmented and localized with over 2,000 competitors in the US alone. Though customer support is important in a large segment of this market, price is the most important consideration in marketing pre-packaged software for specific applications. This market segment is also expected to grow at explosive rates of at least 50% annually to reach a size of US$12.5 billion by 1982.

3. Structural Changes in the Electronics Industry

2.14 The development of the semiconductor industry is having a significant impact on the structure of the electronics industry; one facet of such impact has been the extent of assembly operations required to produce a system. In the manufacture of ICs, the entire circuit is produced at the same time and in batches. The individual components are connected to each other during the manufacturing process. Thus, what had been expensive hand assembly of components is now done in batches at very, very low cost, thereby reducing the need for the offshore assembly houses in developing countries, that had sprung up in the 1960s and early 70s.

2.15 The advent of LSI (Large Scale Integration) technology has triggered a technical revolution far beyond the mere replacement of traditional equipment by smaller, less expensive, and more reliable LSI circuits. The fact that LSI circuits now contain a significant part of the total system technology is causing a most profound change in the structure of modern electronics industry. The traditional component suppliers are becoming the competitors of the equipment manufacturers as evidenced in microcomputers (para 2.12). Conversely, system manufacturers are integrating backwards into the production of components. Accordingly, for any serious attempt in entering the semiconductor field at this time to have a significant long term impact it will have to integrate the semiconductors and systems industries.

2.16 Another modification to the historical structure of the electronics industry which may be emerging is a tendency toward end market specialization. The classical electronics companies, RCA (US) for example, have tended to operate in a wide variety of electronic markets. As operations in each market segment become more complex, it is possible that such companies will find that they must specialize in a few areas and abandon or deemphasize the remaining market segments. Thus, the electronics industry of the future may tend toward companies which are more selective in the markets they attack but are more vertically integrated in order to better serve the selected markets. This trend towards specialization is resulting in companies in advanced countries concentrating their scarce and expensive manpower resources on the latest technologies with explosive growth potential. This move is creating a gap in the already relatively mature technologies, such as low- to medium-complexity semi-conductors, where demand growth is expected to be less attractive. The industry leaders in developed countries are looking at offshore manufacturing facilities to fill the gap. Korea, along with other developing countries with a base in the electronics industry and the required trainable manpower, is in a good position to attract these companies, and also to establish domestic ventures.

2.17 A further shift in the mode of industry operations stems from the growing importance of software as illustrated in expected high growth rates (para 2.13) . The cost of software during the operating life of many systems is substantially larger than the cost of the hardware. This is in sharp contrast to the earlier days of the electronics industry when the hardware cost was the dominant cost of the system. This shift toward software from hardware is particularly pronounced in systems based on microcomputers. A microcomputer can be programmed to perform a reasonable variety of tasks. Thus, each new system need not have new hardware but only new software. This is a return to the general purpose components of yesteryear except with the critical difference of the general purpose component now being a whole system or at least a major portion thereof.

2.18 In summary, the electronics industry in the past has had the system manufacturers in the leading role with component suppliers and software designers as the supporting cast. The design and manufacture of the system contributed the single largest part of the total value added and was in a position of control. This is changing with many of the design decisions now being made by the component supplier, especially the semiconductor manufacturer, while at the same time software, which requires a larger number of skilled technicians and programmers, is overshadowing hardware as the primary cost of ownership. This opens up new possibilities for advanced developing countries like Korea.

2.19 In many ways, Korea, as a country, has the same problems as a company in trying to address the electronics industry of the future. There are finite limits to the rate at which it can acquire technology, train manpower and dedicate financial resources. As a result, it has to focus its efforts in order to match its electronics goals to its resources.

C. The Korean Electronics Industry

1. Evolution and Past Performance

2.20 Korea's electronics industry was established in the early 60s as an import substitution industry based on the assembly of radios and other consumer goods. It gained momentum in the 70s spurred by foreign direct investment, joint ventures with foreign firms, and the growth of domestic firms. Its recent performance is illustrated in the following table.

Korea: Growth of Electronics Industry
(Current US$ Millions)

	1970	1972	1974	1977	% Average Annual Growth 70-77
Production (A)	106	208	814	1,758	49
Exports (B)	55	142	518	1,108	54
Imports (C)	83	179	446	847	40
Export Ratio % (B/A)	52	68	64	63	-
Import Ratio % (C/A)	78	86	55	48	-
% of World Production	0.2	0.3	1.1	1.6	-

Source: Fine Instruments Center (FIC), Korea

Production and exports have increased at average annual rates of 49% and 54% respectively between 1970-77. The industry has also become increasingly more important to Korea's economy and, in 1977, accounted for 11% of the nation's total exports and employed over 140,000 persons. By international standards, however, it is still very small, accounting in 1977 for about 1.6% of world electronics production.

2.21 This growth has been based on: (i) abundance of highly skilled, disciplined, and literate labor at wages about one-tenth and one-sixth of corresponding wages in the US and Japan; (ii) the Government's efforts in providing sound basic infrastructure (transportation, communication, power, etc.); and (iii) an aggressive and balanced development strategy embodied in the Foreign Capital Inducement Law and the Electronics Industry Promotion Law. The Inducement Law offers a competitive incentive package for export oriented enterprises and has attracted a large amount of foreign investment into the electronics industry. The Promotion Law further extends these incentives, as was done for other key industries, such as the machinery industry.

2. Output Composition and Structure of Industry

2.22 As can be expected in view of Korea's labor advantage, the country's electronics production growth has been based on labor intensive consumer products, primarily audio-systems and black and white TVs, and conventional components, such as transistors and capacitors. Entry into the semiconductor field has been limited to assembly of semiconductor devices, and has been followed by domestic manufacture by one Korean company (Samsung Semiconductor). Attempts at penetrating the industrial market have largely been limited to simple telecommunications equipment for the domestic market. Korea's product composition is shown in the following table relative to that of Japan and the US. The data is presented on a value added basis.

Korea: Comparative Composition of Electronic Production - 1977
(Current US$ Millions)

	US		Japan		Korea	
	Value	%	Value	%	Value	%
Consumer	8,119	15.0	8,584	38.2	679	38.6
Industrial	36,703	67.7	7,263	32.3	185	10.5
Components a/	9,409	17.3	6,612	29.5	578	32.9
Semiconductor Assembly b/	-	-	-	-	316	18.0
Total	54,231	100.0	22,459	100.0	1,758	100.0

a/ In Korea US$562 million (or 94%) is attributable to non-semiconductor components, as against much smaller proportions in the US and Japan.
b/ Semiconductor component assembly has no counterpart in US or Japan.

Source: Industry journals and FIC (Korea)

2.23 The table illustrates several aspects of Korea's electronics industry. Korea, like Japan, has emphasized consumer products, reflecting an export oriented strategy, while the US production is largely directed towards industrial use based on its dominance of the computer market and a more broadly developed industrial electronics sector. The variation among the three countries in percentage output resulting from component manufacture is also important. The high percentage in Korea, particularly if assembly of semi-conductor components is included, reflects a focus on the labor intensive, low technology end of the industry. The low percentage in the US on the other hand reflects, both the shift of these activities to offshore locations and a large proportion in the production of complex machines, such as computer mainframes, where a high percentage of value derives from engineering rather than from manufacturing.

2.24 The structure of the Korean industry can also be related to the size of its firms, as shown in the following table, and its product composition.

Korea: Structure of Electronics Industry - 1978

Employees	Number of Establishments				Production Jan. - June 1978	
	1970		1978			
	Number	%	Number	%	US$ million	%
over 2,000	4	3	17	2	426.2	39
1,000 - 2,000	3	2	30	4	170.3	16
500 - 1,000	9	5	62	9	117.8	11
100 - 500	41	23	294	42	274.7	25
below 100	118	67	304	43	95.0	9
Total	175	100	707	100	1,084.0	100

Industry growth has been accompanied by a large increase in the number of electronics companies, from 184 to 691 between 1970-77 and to 707 by mid-78. The size of the firms also increased significantly. By mid-78 about 57% of the firms employed over 100 persons, compared to only 33% in 1970. These firms now account for over 90% of the industry's output. Of these 707 firms, 495 are domestic operations, 168 are joint ventures with foreign firms, and 44 are wholly owned subsidiaries of foreign firms. In terms of output value, the domestic firms accounted in 1977 for about 40% of total Korean production, the joint venture firms for 22%, and the foreign companies for the remaining 38%. The local firms comprise a number of large companies (such as Gold Star, Taihan, Samsung, and the Oriental Precision Company (OPC)) and principally small operations with less than 200 employees. The joint ventures are generally intermediate in size averaging several hundred employees, and the subsidiaries owned by world industry leaders (such as Fairchild, Motorola and American Microsystems (US), Toshiba (Japan), Signetics (owned by Phillips, Netherlands)) are large ranging between several hundred and several thousand employees. The handful of large Korean companies and some medium sized joint ventures dominate the consumer and industrial end-product markets with the production and assembly of audio-systems, TVs, telecommunication products and, in a single case, minicomputers. The small local companies cater to the non-semiconductor component market domestically and for export. The large wholly owned foreign subsidiaries are principally engaged in, and account for the bulk of semiconductor component assembly, almost entirely for re-export to their parent corporations.

3. Exports and Imports

2.25 The structure of Korea's electronics exports and imports is shown in the following table.

Korea: Structure of Electronics Exports and Imports - 1977
(Current US$ Millions)

	Exports		Imports	
	Value	%	Value	%
Consumer	437	39.5	76	9.0
Industrial	103	9.3	122	14.4
Non-semiconductor Comp.	263	23.7	563	66.5
Semiconductor Components	305	27.5	86	10.1
Total	1,108	100.0	847	100.0

Source: FIC (Korea)

Components, followed closely by consumer end-products, are Korea's largest exports. Components also constitute its largest import suggesting a narrow domestic product base. Furthermore, despite a large volume of domestic output of certain products, others are not locally available and must continue to be imported.

2.26 The geographical breakdown of Korea's exports and imports, shown in the following table, illustrates the country's dependence on Japan and the US, particularly for its imports with a somewhat broader distribution of its exports. The import reliance on Japan and the US is indicative of its technological links with these countries and Korea's continued dependence on its sources of technology for its component needs.

Korea: Breakdown of Korea's Exports/Imports of Electronics - 1977

Destination/Source	Exports	Imports
USA	45	34
Japan	22	55
Europe	17	6
Others	16	5
	100	100

Source: FIC (Korea)

4. Industry Weaknesses

2.27 The direction of growth of Korea's electronics industry, discussed above, has been influenced by several constraints. First, a high cost of capital and a corresponding desire for a high return on investment, has discouraged approaches requiring large investments in areas such as product or process development, which typically would have resulted in high and prolonged amortization of costs. Second, the lack of knowledge about product design trends and of experienced design personnel has encouraged Korean companies to seek and rely on products designed elsewhere and proven in world markets. Third, the absence of required production and other support services has further discouraged entry into new areas such as semiconductor manufacture. Of the broad range of functions performed by the "semiconductor service industry" in other countries, Korea has acquired competence only in assembly. Fourth, the newness of Korea as an electronics producer has precluded it from having an extensive distribution system. This lack has forced reliance on foreign wholesale distributors, which has kept Korean companies away from the ultimate markets and denied them direct knowledge of market trends.

2.28 The above factors have combined to push the development of the Korean industry in the direction of minimal own development, product design, and marketing. The industry has favored receiving licenses for proven and mature product designs, particularly Japanese, leaving sales activities to others. There is, however, an increase in independent marketing efforts lately in consumer goods, such as TVs, particularly in Europe and in developing country markets. In summary, therefore, despite its impressive growth, the Korean electronics industry, by comparison to that of advanced countries, generally lacks breadth and depth in design, technology and marketing.

D. Development Plans for the Korean Electronics Industry

2.29 The Fourth Five Year Plan (1977-81) for the electronics industry calls for US$4.7 billion in production and US$3.0 billion of exports by 1981 (in current dollars). The latter is one fifth of the country's export target for that year. The achievement of these targets is essential to Korea's ability to maintain its overall growth momentum, and therefore it has to expand exports, on which further growth, to a large extent, is based. The Government and industry plan to achieve these ambitious targets by bringing the composition of Korean electronics production by 1986 closer to the composition now existing in the Japanese industry (para 2.22). This would be done by concentrating on the development of industrial electronics primarily for the domestic market, continuing emphasis on consumer electronics as a major export, backward integration into raw materials and components required by end-product manufacturers, and the development of a broad technological base. While the achievement of these targets would bring the Korean electronics industry by 1981 up to the scale of Japan's electronics industry about a decade ago (1967), by present standards, the Korean output will remain relatively small. It would account for only around 3% of the total world production up from 1.6% presently (para 2.20). The Korean share of the electronics world trade (excluding shipments between West European markets) would be about 6% compared to about 40% each for the US and Japan. In the semiconductor field, which is the project's primary emphasis, Korea's share in world production and exports is expected to be around 2 and 3% respectively. In the digital systems area, it would be even less significant.

2.30 The worldwide shift within the consumer electronic sector from the developed to the developing countries on the basis of lower production costs, the rapid growth of industrial electronics, together with the technological trend toward vertically integrated operations, principally confirms the soundness of the Korean development plan in its new direction and emphasis. The technology for a large segment of consumer goods, such as for monochrome television sets and radios, is relatively mature, and Korea has only to attain a moderate degree of development capability to incorporate the necessary improvements in these products. Domestic component manufacture could then be shifted away from the present focus on exports, and be geared to meet the component needs of consumer goods manufacturers. This would increase Korean value added in electronics output and reduce the present reliance on component imports (para 2.25).

2.31 The desire to shift emphasis in component manufacture is prompted by the evolving semiconductor and particular LSI circuit technology. These technologies are fast replacing non-semiconductor components and labor intensive assembly of discrete semiconductor components (which now account for all of Korea's component output). In about 10 years, semiconductors are expected to account for as much as 12-15% of final product manufacturing cost in advanced countries compared to a current 6-8%, through the increased use of LSIs thereby reducing the labor component used in assembly operations. Furthermore, because of its rapidly increasing wages, Korea will be facing stiff competition from other developing countries in the shrinking labor intensive assembly operations. Similarly, the emphasis on industrial electronics reflects the fact that this is expected to be the fastest growth area in electronics in the next 20-30 years.

2.32 A large part of the conventional technology required for this development can be readily obtained through licensing agreements or joint venture operations within the existing Korean incentive framework. The development of a technological base in the semiconductor and the digital systems fields, which as noted have become the backbone of the electronics industry, will however require special attention and effort. Consequently, the following sections will review the prospects and development strategy for the semiconductor and digital systems industries in Korea.

E. The Semiconductor and Digital Systems Industries in Korea

1. Semiconductors

2.33 The consumption of semiconductors in Korea's electronics products was US$60-70 million in 1977; of these only US$16 million was produced by the sole Korean manufacturer, Samsung Semiconductor (para 2.22), and by one foreign company, the rest were imported from the US and Japan. In addition, about US$60 million worth of semiconductors was imported by assembly houses for assembly and re-export. The demand for semiconductors in Korea in the next few years can be expected to grow, in physical terms, by more than 40% per year well above the projected growth rate (27%) of electronic products as a whole. Most Korean products are based on dated designs and incorporate only part of the full IC potential. The introduction of new products, which must be preceded by more design, will further increase the demand for ICs beyond the average growth rate of the electronics industry. Depending on the pace of technological change introduced by the industry and the effort by the Government to attract leading foreign companies to Korea to establish joint ventures with local firms , the domestic demand for semiconductors is expected to range between US$240-300 million by 1981, corresponding to 5-7% of the value of total target electronic production (compared to the 6-8% in advanced countries presently). An export market for Korean made semiconductors may be expected, which might increase this figure.

2. Digital Systems

2.34 In digital systems, Korea has no capabilities in the computer mainframe and small/medium computer area and none is expected in the foreseeable future. In the minicomputer area, it has indigenously completed one project which is equivalent in complexity to the development of a minicomputer -- a private branch telephone exchange (PBX) communication system. There is one minicomputer manufacturer in Korea carrying out what is primarily an integration of imported processors and peripherals into systems. Foreign competition is strong and able to offer a leasing alternative, thus significantly constraining the prospects of the local manufacturer. The microcomputer, which is the fastest growing digital systems area, is the most promising field for Korea, and a number of end-equipment manufacturers have already been established and others are also considering the development of indigenous microprocessor based products including add-on peripherals (paras 2.11 and 2.13) such as terminals and key-entry systems. Scarcity of adequately trained digital system designers, long lead times on prototype parts, lack of software

development tools, testing and other basic services such as supply of two-sided printed circuit boards (PCBs) have constrained these programs. These problems are, however, not insurmountable, and the industry could grow rapidly in response to the expected strong growth in demand and increased availability of trained programmers. With the active support from a technological infrastructure (design service, etc.) and an active effort to attract joint ventures, production in Korea of small digital systems could increase from virtually nil to about US$50 million by 1982.

F. Development Strategy

2.35 The acquisition and development of semiconductors and digital systems technology is essential if Korea is to develop a viable electronic industry. The timing is also opportune. In the semiconductor industry, the rapid growth is prompting companies in advanced countries to look at the possibility of establishing overseas manufacturing facilities for relatively mature technology such as low- and medium- complexity semiconductors so as to concentrate their scarce and expensive manpower on more advanced technologies, products, and markets (para 2.16). The markets for products based on these relatively mature technologies are expected to continue to be sizable, though not growing as rapidly as those based on the latest technologies. Facilities to cater to these markets and thus fill the gap created by companies in advanced countries moving out of these areas, are expected to be established in developing countries, such as Taiwan, the Philippines, and Korea. This trend is already in evidence in Korea. Samsung, presently the sole Korean semiconductor manufacturer, is expanding operations in assqciation with a US manufacturer. Toshiba (Japan) is expanding its Korean operations in semiconductor manufacture. American Microsystems International (US) has also formed a joint venture in this area with Goldstar. A number of other world industry leaders (such as Motorola, Fairchild, National Semiconductor, all of the US) are discussing joint venture possibilities in Korea. As further evidence of this interest, a number of these companies have started or are considering training Korean engineers in their plants. This is likely to considerably simplify and facilitate Korea's task of acquiring the required technologies.

2.36 Potentially, Korea has a significant cost advantage in a number of semiconductor and microprocessor applications areas over advanced countries. As shown in the table below, estimates of the cost of manufacturing a typical medium complexity semiconductor wafer amount to about 65% of the equivalent cost in the US, assuming equal yields and reasonable production volume. Korea's advantage is based on low cost skilled labor and engineering resources which results in a close to 5 to 1 differential in the categories of direct and indirect labor, and overhead. Thus, once yield competitiveness is achieved, Korea can be expected to have a real price advantage even after allowing for cost of technology purchase and training.

Comparison of Manufacturing Costs
of a Semiconductor Wafer in the US and Korea

	U.S.	Korea
	(US$/Wafer)	
Starting Material (3" wafer)	5.0	5.5
Photo-Masks	2.5	2.8
Chemicals, Gases, Water	3.0	3.3
Direct Labor	5.0	1.0
Indirect Labor	2.0	0.5
Overhead	12.6	2.7
Equipment Depreciation	5.0	5.5
Sub-total	35.1	21.3
Total (with 20% yield loss)	43.9	26.6

2.37 In the systems area, the introduction of the microprocessor has opened a broad range of untapped opportunities that will increasingly require a large number of skilled programmers and digital system designers. A large consumer equipment segment can provide a large domestic market for microprocessors and also allow equipment manufacturers to significantly upgrade their products, for example by introducing microprocessor-based digital tuning systems into audio and video products. The growing importance of microcomputers and software (paras 2.12, 2.13, and 2.16) will increasingly require large numbers of digital systems designers and skilled programmers. In these price competitive areas, where engineering accounts for a substantial proportion of the manufacturing cost, Korea has a potential large comparative advantage, based on wage levels that are much lower than those in the US, Japan, and Europe.

2.38 In pursuing these opportunities, the choice of the proper technology and of the methods of technology acquisition is of paramount importance. The development and diffusion of the semiconductor industry in the US, Europe and Japan, can provide Korea with some insight. The spectacular growth of the US industry is attributd to a number of factors among which are the considerable R&D effort (10% of sales), direct support from the US Government and availability of venture capital that has enabled scientist/entrepreneurs to start their own firms. An equally important factor in the diffusion and spread of know-how has been the rapid movement of people within the industry and exchange of information through cross licensing. This has enabled US firms to complement each other and to quickly absorb the technologies required for different stages of manufacturing (circuit design and layout, mask making, various stages of diffusion, ion implantation) and to concentrate on systems design, process and market development. Equally important has been the large network of specialized services companies that has emerged to support all stages of development of the industry (equipment manufacture, integrated circuit design and layout, mask-making, wafer-fabrication, IC testing, assembly, and general consulting).

2.39 In Europe, foreign subsidiaries of US multinational corporations have provided the mechanism for the swift diffusion of technology and have captured a substantial share of the European market. To efficiently compete with US firms, European firms more recently have narrowed their field of operations primarily to consumer electronics with a high, though relatively stable, technology content and have spread the cost risk and effort among themselves by joint research and development programs. Recently, the UK has initiated several programs amounting to over US$300 million to encourage development of the microelectronics industry. Japan acquired its technology principally through licensing supported by training, and shared development efforts among Japanese companies.

2.40 With the advent of LSI technology, the traditional technology diffusion process is undergoing a drastic change. Licensing alone is losing its effectiveness as a mechanism for acquiring the latest technologies. The progress of LSI circuits has now given the US over 60% of the market. To bridge the technological gap in the electronics field in Japan, the Ministry of International Trade and Industry (MITI) encouraged the large computer firms to reorganize into two VLSI (very large scale integration) research teams (Fujitsu-Hitachi-Mitsubishi and Nippon Electric-Toshiba Electric). MITI, the perennial matchmaker, is footing half the research bill (estimated at around US$500 million equivalent), and has established an electronics RD&E laboratory to assist the rest of the industry.

2.41 The experience of the semiconductor and systems industries suggests that the most effective way of transferring technology has been through training and the continuous exchange of people and information from expert to expert. This is best done when the supplier of technology has a continuous interest in providing his know-how to the technology recipient. This situation exists in carefully conceived joint venture arrangements, which complement basic strengths of the parties involved and also pertains to manufacturing contracts where the recipient gets his technology as a package in return for supply of reliable and price competitive products. By contrast, licensing arrangements alone, which are largely based on patents and do not include transfer of technological and manufacturing know-how and possible market links, have been less effective.

2.42 The difficulty in obtaining technology through licensing is particularly severe where the recipient lacks an established technological base. It is further accentuated by the rapid pace of technological change in the electronics industry, and the need therefore to quickly enter a market before a product either becomes obsolete or competition so strong that product prices decrease to a level where they are no longer attractive. In these instances, the technology recipient lacks the capability to keep pace with developments in the licensed technology and perennially lags behind competition. Accordingly, to acquire a technological base rapidly, a number of European and Japanese companies, in the last few years, have purchased part or all of US companies. Similarly, an increasing number of leading US companies are entering into cooperative RD&E arrangements among themselves to share the risk and benefit of the increasing cost of research in advanced technology areas.

2.43 The preceding discussion suggests that Korea has to concentrate initially on a few technologies that allow upgrading of the design and reliability of existing products, and at the same time permit entry into new areas where Korea has an emerging competitve advantage (paras 2.36 and 2.37). In addition to ensuring focus on these technologies and products, Korea has to attract foreign companies that are technology leaders, and can provide Korea with a continuous inflow of know-how in new areas, where these leaders are already investigating possibility of securing sources in low-cost off-shore locations (para 2.35). Even then, the effort will require substantial design and manufacturing know-how as well as an expensive infrastructure beyond the individual capabilities and resources of Korean or joint venture firms. Accordingly, direct Government intervention, such as in the US and Japan, is needed to stimulate, complement, and support the effort of the industry. The cooperation of industry, research institutions, and Government in formulating and financing a development program is essential. It is expected that these ingredients can be brought together in Korea.

2.44 A major focus of this Government support in Korea would be to provide the necessary infrastructure and specialized services until such time that the size of the industry reaches a critical mass which can sustain a profitable supply of such services. A central facility providing these services could also be used for on-the-job training to complement the training of Korea's engineering undergraduate universities and the professional graduate programs of the Korean Advanced Institute of Science (KAIS).

2.45 The Korean Government has devised a balanced financial incentive system for RD&E (as embodied in the Technology Development Promotion Law, para 2.21). However, in view of the perceived high risks associated with the rapidly changing electronics technology, the requirement of a relatively large amount of capital and the present small size of the local market, Korean companies have been reluctant to make significant investments in RD&E. Accordingly, direct Government participation in financing and sharing in the cost of research, development and engineering, as has been successfully demonstrated particularly in the US and Japan, can effectively spread the costs of these activities across a number of individual companies and catalyze an effective program of development in technologies new to Korea.

2.46 The proposed project will combine these elements, and be an important vehicle for Government support to the electronics industry. It will provide industry with up-to-date specialized services that cannot be provided by individual companies thus promoting development into new areas by creating the environment necessary to attract and assist joint-venture and domestic companies. It will serve as a focal point for the initial transfer of advanced technologies to the Korean industry, including required training. It will manage an RD&E fund and share with the industry the cost and benefits of RD&E work in areas where Korea can compete effectively in the world market and upgrade the capabilities of a significant segment of the electronics industry. Korean industry, which has been directly involved in preparing and formulating the proposed project, has demonstrated strong support for these objectives.

III. THE KOREA INSTITUTE OF ELECTRONICS TECHNOLOGY (KIET)

A. Evolution

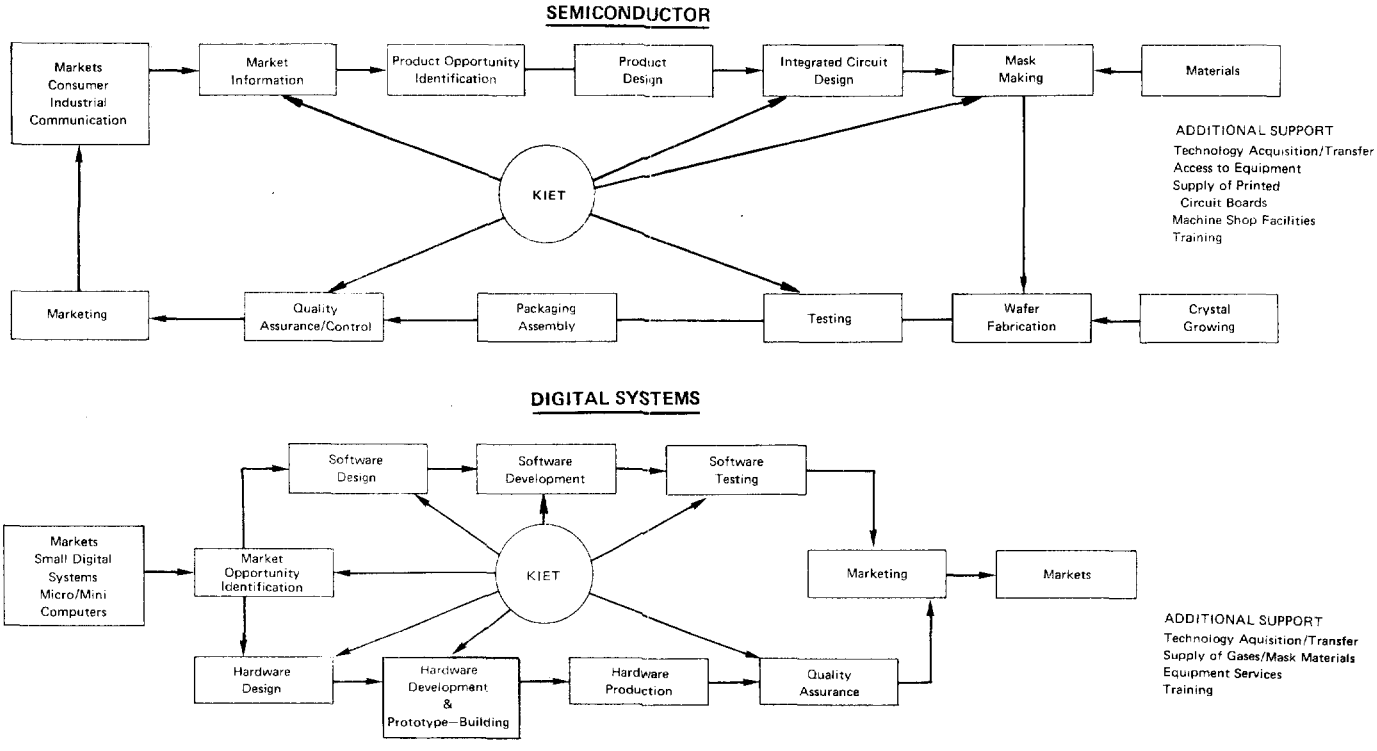
3.01 KIET was established in December 1976 under the Specific Research Institute Promotion Law. Under this law, KIET is an institute of the Government of the Republic of Korea responsible to the Ministry of Commerce and Industry. Its creation reflects a significant commitment by the Government to establish a technological base in the electronics industry. Its charter includes a broad range of functions in the field: planning and coordination of RD&E; technology acquisition, development and dissemination; direct services to industry; and market research and development. KIET is an outgrowth of the Semiconductor Development and Systems Units, which were established within the Korea Institute of Science and Technology (KIST) in 1974, as small-scale research laboratories for projects in wafer fabrication and systems development. The Bank has played an important role in developing KIET. KIET's orientation has been modified from that of a relatively isolated research facility to a service and development organization. It is now capable of catering directly to industry requirements by providing essential support services, undertaking RD&E activities for industry, and introducing and developing new technologies in a production-oriented environment.

3.02 KIET's efforts so far have focused on the recruitment and training of its staff, and preparation for its development into a functioning institute. A UNDP project (para 1.07), with the Bank as executing agency, has been vital to this effort. The project provided US$400,000 for: the appointment of a technical advisor and several short-term consultants to KIET for both project preparation and start-up of KIET's US liaison office; architectural/engineering assistance in the design of KIET's semiconductor building; and, training of KIET staff.

B. Role and Functions of KIET

3.03 KIET will act as a catalyst in the technological development of Korea's electronics industry into the semiconductor and digital systems areas. KIET's role, which has been planned in conjunction with industry representatives to maximize responsiveness to industry's needs, is illustrated in the chart below. Primarily, it will focus on critical functions that are either beyond the current technological capabilities of industry or cannot be undertaken profitably in view of the present size of the industry, but are vitally needed for its development.

KIET: Role in Semiconductor and Systems Industries



These functions include:

(i) Production Support Services such as custom design of semi-conductor ICs and digital systems; supply of process inputs--masks, wafers, printed circuit boards (PCBs), and pure gases; testing, quality assurance and control; equipment services; training; and market research and analysis. KIET will have the capabilities of the "service industry", which performs these functions on a specialized basis in the US (para 2.38). In providing these services however, KIET will perform a function different from that performed by commercial services companies. In light of the present stage of development of Korean industry KIET will emphasize the diffusion of manufacturing know-how aimed at building domestic technological capability. Thus, unlike the US service industry which provides the above services in long production runs, KIET in many instances will provide them for only a short period of time followed by trouble-shooting and backup support, particularly in the early stages of production. Further as part of the service function, KIET will emphasize the education and training of industry personnel. As a development institution it will provide a continuously advancing mix of services to spearhead the pace of industry's development. Easy access to these services in Korea is expected not only to encourage small and large companies to enter these industries, but also help attract potential joint-venture operations to the country; and

(ii) Product and Process Development focusing on areas where Korea can compete effectively in world markets, such as ICs for consumer applications (clocks, audio-equipment, TV, and household appliances), and software/hardware for small digital systems (numerical and process controls, communication systems, micro- and minicomputers, and terminals). Major development projects, such as the development of an advanced color TV and a microcomputer will be executed under the RD&E program. KIET will share the risks and benefits of these projects with industry sponsors.

3.04 The combination of service and development functions distinguishes KIET from conventional research institutes. Another feature of KIET is that it will carry out its semiconductor process development work on production equipment. This arrangement is normal in the semiconductor industry, and significantly reduces the lead time and costs associated with transferring research results to a production setting in industry. It will also enable KIET to undertake production of wafers, both, as a means of acquiring process technology from selected overseas companies in return for reliable supply of product (wafers), and as a means of developing manufacturing know-how, which can subsequently also be transferred to local industry. This production-cum-market-development function is expected to be particularly useful to industry, since unlike most research institutes, KIET could then assist industry in the critical early stages of commercialization, beyond the research and development stage. KIET's basic principle of operation in its production of wafers will be to directly assist and serve industry and not compete with it. It intends to work with technologies perceived as too risky by industry initially and limit production to serve as a temporary back-up "second source", once production has been transferred to industry. As reliable domestic supply of a product is assured, KIET will discontinue its production and redirect its resources to other required technologies.

C. Location

3.05 KIET is located temporarily in Seoul, and is using semiconductor facilities at KIST for training and staff development. KIET will move to a semiconductor-systems industrial estate in Gumi in 1980 (see below). Gumi, around 200 km southwest of Seoul (Map IBRD 14069), is already a major center of electronics assembly operations in Korea, and with the development of the semiconductor-systems estate, it would effectively become the base for the bulk of the country's electronics activity. Site preparation and civil works for KIET's facilities are already underway at Gumi and are expected to be completed by the end of 1979. In addition to KIET, the estate is planned to eventually house 12 semiconductor and 16 systems companies, with a projected total employment of around 9,000 persons. Access to KIET resources and services is expected to act as a major incentive in attracting companies to the estate; some major electronics companies have already acquired sites.

D. Organization

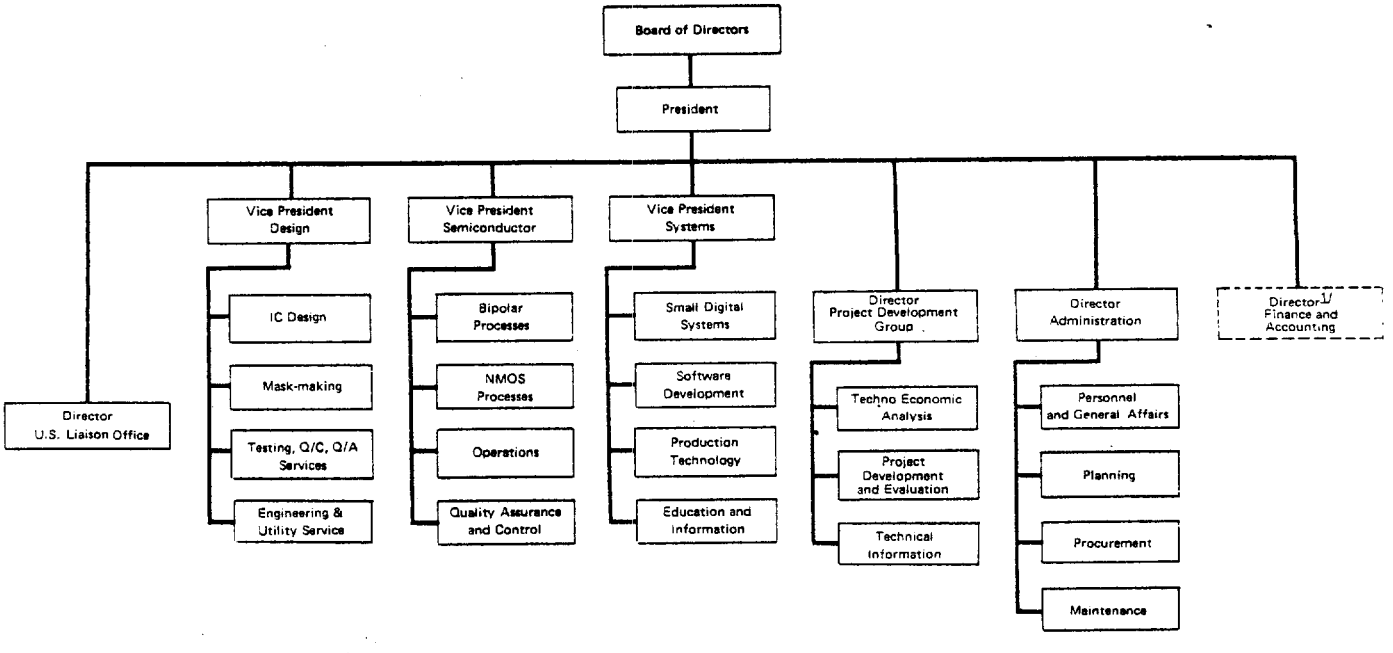
3.06 The Board of Directors of KIET comprises 12 regular directors, an honorary director and an auditor. Four of the directors are drawn directly from the Government, and represent the Economic Planning Board (EPB), and the

Ministries of Commerce and Industry (MCI); Science and Technology (MOST); and Communication (MOC). Two other directors, the President of KIET and the President of the Electronics Industry Association of Korea are ex-officio members. The remaining directors are selected for a four-year term from industry, universities and foreign assistance organizations. The Board presently includes top executives of five large private electronics companies. The significant representation of both Government and industry in the policy-making function is designed to ensure consistency with Government policies and responsiveness to industry requirements.

3.07 The President of KIET reports directly to the Board, and is responsible for implementing the policies established by it. He is appointed by the Board for a term of four years (extendable by one more term), subject to the approval of MCI. The present President of KIET is Dr. S.J. Hahn, who was formerly President of KIST for six years (1972-77). Dr. Hahn is a capable scientist and administrator who has contributed significantly to the development of KIST; he is widely respected in both Government and industry circles, and well known outside Korea. His stature will be particularly important in continuing to attract experienced and talented professionals to KIET.

3.08 The organization of KIET is shown in the following chart.

KIET: Organization



1/ Independent unit for Finance and Accounting to be established under a Director by the end of June, 1979.

It reflects an "engineering service" rather than a "research" orientation. KIET is organized as a service operation along the three major functional lines: semiconductor design, semiconductor processes and systems. Each of these groups is managed by a Vice President, who is responsible for planning, executing, and monitoring the service and RD&E activities in his area. The three incumbent Vice Presidents have significant academic training and industrial experience in the US in their respective fields and are capable of directing KIET's primary activities. The Vice President-Design will be responsible for IC design, the related area of mask-making, and also for testing, quality assurance and control, engineering and utility services; the Vice President-Semiconductor Processes, for all wafer fabrication and processing activities; and, the Vice President-Systems, for all systems-related activity including training and advisory services to industry. The RD&E program will also be executed within these functional lines and be under the control of an RD&E Review Committee (para 4.26). The three Vice-Presidents together with the President will be responsible for coordinating KIET activities. Senior management will be assisted by a reputable technical advisor and short-term consultants (presently being financed under the UNDP Project). The technical advisor has played an important role in training and project formulation and is expected to continue to provide necessary guidance. Since this is critical in supplementing KIET management's capabilities, KIET has agreed to retain at least through the end of 1982, a technical advisor, whose experience and qualificatons are acceptable to the Bank.

3.09 The activities of the three operational divisions are supported by three staff groups: Administration, Project Development, and the liaison office in the US. The Administration section is presently responsible for functions such as finance, personnel and procurement. In view of the complex financial and accounting requirements related to KIET operations and RD&E, a strong financial capability is regarded as essential. Accordingly, KIET has agreed to establish a separate financial department under an independent Director by the end of June 1979. The Project Development group will conduct market research, analyze the products and technologies to be developed by KIET, and coordinate the preparation of planning and policy documents for the Government.

3.10 The US liaison office was established in the San Francisco Bay area (known as Silicon Valley to reflect the concentration of semiconductor activity) in early 1978, to perform a broad range of important functions. The office is staffed by a permanent Director guided by the technical advisor (para 3.08) and a pool of technical staff on assignment from KIET. In the implementation phase, the office will assist KIET in procuring equipment, key technologies, special materials and supplies. It is also expected to maintain close contact with major electronics activity-centers in the US and Europe, and assist both Korean industry and KIET in market- and technology-related areas (contact with Japan would be maintained directly from Korea). In view of the rapid response required in the electronics field, an ability to respond quickly to industry and KIET requests, particularly with regard to purchasing spares, materials and supplies, is vital to the office's success

in fulfilling its role. Present administrative procurement procedures require ratification of each individual bid by the Korean Government and prior approval of each purchase, and lead to substantial unnecessary delays. The Government has agreed to work with KIET to develop simplified procedures to enable quick and efficient procurement.

E. Coordination with Industry

3.11 As noted, a close working relationship among Korean industry, Government, and KIET is critical to KIET's success. At the policy level, interaction between industry, Government, and KIET is incorporated into the structure of the Board. In addition, three working groups (with a composition given below) have been established during project preparation to ensure KIET's responsiveness to industry needs. Industry representatives in the groups have been particularly enthusiastic and clearly foresee KIET's usefulness to them. These groups have contributed significantly to project design and preparation and are expected to continue to play a useful role through project implementation. The groups are the: (i) Facility Group comprising representatives of industry, Government and KIET management to develop final plans for building design and equipment selection; (ii) Work Program Group comprising representatives of industry and KIET management to jointly develop KIET's initial direction and program for service and RD&E activities; and (iii) Training Group comprising representatives of industry, the Korea Advanced Institute of Science (KAIS), and KIET management to formulate KIET's training program, which will also include industrial personnel as trainees. The latter two groups will continue to meet through project operation to periodically review KIET's work and training programs. At the professional level, links are expected to be built through easy access for industry personnel to KIET staff; cooperation in research teams, as provided for under the RD&E program; and joint participation in training programs.

IV. THE PROJECT

A. Objectives and Scope

4.01 The primary objective of the project is to stimulate the development of a technological base in the Korean electronics industry to achieve the planned high growth level. The proposed project aims to develop KIET to play a central role in this growth, and accordingly to: (i) provide technological infrastructure of essential production and support services; (ii) assist in the required training and technical manpower development; (iii) lead the industry in acquiring and developing semiconductor and systems technologies; (iv) carry out RD&E for industry and share the financial risk of these activities with industry; and (v) explore and develop export market opportunities for Korean electronics industry overseas.

4.02 The proposed project comprises the following two components: (i) Development of KIET: The project would finance (a) physical facilities for KIET: land, buildings and ancilliary services; equipment; and specialized

utility and support systems; and, also (b) training, technical assistance and technology acquisition; and (ii) RD&E Program: Funds would be provided to finance RD&E projects carried out at KIET. These would include: primarily industry-sponsored projects where KIET will share costs and benefits with the sponsors; and a small proportion of longer-term projects initiated by KIET. The sections below detail these two components of the project.

B. Development of KIET

1. Physical Facilities, Infrastructure, Raw Material Supply, Ecology

4.03 Land and Operational Buildings. KIET will be located at a site occupying 230,000 sq. m. in the Gumi semiconductor - systems estate. The proposed layout of KIET facilities planned under the project is shown in Annex 4-1.

4.04 All semiconductor-related activity including IC design, mask-making, testing, and wafer fabrication will be concentrated in one building with a working area of 8,700 sq. m. The design of the building is critical in view of the special environmental requirements of semiconductor activity. It incorporates special process systems to deliver: large amounts of power to support processing temperatures as high as 1,200°C, large amounts of highly conditioned air to maintain cleanliness and temperatures within tolerances of 1°C, special gases (primarily nitrogen, oxygen, hydrogen), and DI (deionized) water. To transfer semiconductor building technology to Korea and to minimize the foreign exchange cost of this transfer, the KIET building has been designed jointly by a competent Korean firm and a leading US architectural/ engineering company responsible for many of the latest semiconductor buildings in the US (the assistance was financed under the UNDP project, para 3.02). The US company provided the overall design concept, is supervising detailed engineering carried out by its Korean counterpart, and will also monitor building construction. The building incorporates the most advanced technologies, and is expected to provide at least 10-15 years of service without serious modification; also the design permits easy internal rearrangement and expansion of semiconductor capabilities. The building is expected to serve as a model for Korean industry in planning its facilities. In view of its critical nature, KIET has agreed not to undertake any major deviations from agreed designs without prior Bank approval. For day to day supervision of building construction, KIET plans to recruit a semiconductor facility expert by March 1979; KIET has agreed to appoint and retain the expert for at least until one year after the start-up of the semiconductor facility so that the expert, besides supervising construction and installation of equipment, could adequately train counterpart Korean staff.

4.05 A second building will combine administrative and systems activities in a relatively conventional structure of around 4,000 sq. m. with some special support equipment for climatic control for systems work.

4.06 Support Facilities: The project provides for a training center for industry personnel at the KIET site, and the staff of the liaison office, already established in California (para 3.10). A power substation and an emergency generation system to assure an uninterrupted power supply to the processing equipment at KIET will also be included. A utility plant will be installed to provide for chemical and gas storage, air-handling and chilling equipment, and a deionized water plant. Since hydrogen of the required purity is not readily available and difficult to transport, a pure hydrogen generating plant will also be provided.

4.07 Physical Infrastructure: A road linking the estate (and therefore KIET) to Gumi city has already been completed. Dormitories for around 90 single staff, and apartments for around 60 families are also included in the project (additionally, MCI has provided KIET with 40 apartment units in Gumi for a 10-year period). There will also be dining facilities on site for employees, industry trainees, and visitors. Further, the Government plans to support the development of the semiconductor-systems estate through the provision of educational facilities, including an electronics technical school (which has already been located in the estate), housing, medical care facilities, and adequate support systems. The Government has agreed to provide such infrastructure in line with the project schedule. Since KIET is one of 29 potential occupants of the estate, the proportion of the cost of this Government-provided infrastructure attributable to KIET is negligible, and has not been included in the analysis of the project.

4.08 Raw Material Supply: A large proportion of the raw materials required by KIET--wafer- and mask-blanks, special chemicals--will be imported from overseas on a continuous basis; these materials are readily available. Of the required gases, nitrogen and oxygen, are available in adequate quantity and will be purchased locally, and purified on-site. Several bulk chemicals will also be procured locally. Gumi is adequately connected by road with the major sources of these supplies, particularly Seoul, which will be the entry point for most imports.

4.09 Future Expansion: The large area available at the KIET site allows for significant future expansion of KIET. Tentative second phase expansion plans include a separate testing center, and a separate computer hardware laboratory. Expansion capability in the semiconductor area is already incorporated in the semiconductor building design (para 4.04). The need for expansion would be based on the performance of KIET under the project and will require Bank approval (para 6.15).

4.10 Ecology: KIET activities involve a number of corrosive chemicals and toxic fumes and gases, in the semiconductor building. The building design incorporates advanced techniques for collection and removal of these from the work area to maintain an ultra-clean and safe working environment. The project includes scrubbers for gaseous exhausts, an acid neutralization system, and disposal systems for treating wastes from semiconductor and printed circuit board (PCB) processing. Overall, the facility is designed to meet the latest US environmental standards. KIET has agreed to implement and operate its facilities in accordance with agreed ecological designs and standards.

2. Technology Acquisition, Training and Manpower Development

4.11 The development of KIET's technological capability will be accomplished through a directed effort of manpower recruitment and training, and technology acquisition. Experience in the electronics industry demonstrates the effectiveness of training, and of association with a source of technology that has a continuous interest in ensuring technology transfer to the recipient, as methods of acquisition of technology. It also shows the limitations of licensing alone as a means of acquiring technology (para 2.42). Accordingly, for technology acquisition, the project emphasizes: (i) training of staff, including on-the-job output-oriented experience in US, Japanese and European companies; (ii) recruitment of staff and consultants with familiarity and experience in the technologies selected; (iii) contractual production and service arrangements with foreign firms in the selected technologies, where KIET, as the contractor, receives the technology as part of the order specifications in return for competitive and reliable supply of product/services; (iv) purchase of advanced equipment (as part of its physical facilities) that incorporates much of the technology, supplemented by training provided by vendors of such equipment; and (v) purchase of technology in highly specific cases. KIET is exploring a number of possibilities and combinations along the above lines, as part of a continuous technology acquisition effort. The technologies KIET will initially focus on are: the linear bipolar processing technology for consumer applications and the NMOS processing technology for systems and memory applications; IC design, mask-making, testing, quality control and quality assurance (systems and procedures) know-how; and a range of systems hardware and software technologies. Of these, the processing technologies (linear bipolar and NMOS) will most likely be licensed. As noted (para 2.07), these are the dominant technologies used by a number of semi-conductor companies around the world, and are expected to be available to KIET at reasonable cost. Funds for their purchase have been provided in the project based on recent license fees. The arrangements already concluded and being discussed are listed in Annex 4-2. Further arrangements will be concluded in the coming years, on a continuous basis.

4.12 Training of staff is expected to be the most important means of developing technological capability. A training program comprising three major phases, supplemented by a continuous ongoing training effort at KIET, is planned. These phases are: (i) basic training at the Korea Advanced Institute of Science (KAIS), other Korean universities which offer programs in electronics, and courses at KIET itself; (ii) overseas group and fellowship training under formal training schemes in academic and industrial settings; and (iii) on-the-job experience in overseas companies in selected technologies. Industry participation will be invited and actively promoted in all these programs. This is expected to serve the dual purpose of training industry personnel and fostering close working relationships between KIET and industry staff. Additionally, the project provides for attendance at international conferences and seminars and the invitation of foreign experts for brief periods to conduct workshops/brief programs for industry and KIET personnel. Supported by these programs, and a vigorous local and overseas

effort, total manpower at KIET is expected to reach around 700 persons by 1982. Annex 4-3 gives details of the staff build-up at KIET and its training, conference-attendance and expert-invitation programs.

4.13 In view of the rapidly changing nature of electronics technology, and accordingly Korean industry's and KIET's needs, the technology and manpower requirements are expected to evolve continuously. Accordingly, KIET will submit, during disbursement of the Bank loan, an annual technology acquisition program along with the recommendations of its technical advisor for Bank review and consultation (para 6.17). The training and expert invitation programs will be similarly submitted for Bank review and approval. Implementation of these programs will be monitored on a quarterly basis.

4.14 A key element in enabling KIET to attract and retain sufficient numbers of qualified staff will be the compensation level which KIET, as a Government institute, is permitted to provide. At present, KIET's salaries and benefits are roughly comparable with industry, although industry salaries are rising rapidly. In order to allow KIET to maintain employee compensation at competitive levels, the Government has agreed to review the compensation structure from time to time to maintain competitiveness, and to allow KIET to reward employee performance through an incentive system. Further, KIET will, by September 30, 1979, in consultation with the Bank, adopt and implement such an incentive system.

3. KIET's Service and Development Program

4.15 The facilities to be developed and the technological capability established under the project will provide KIET with significant service and development capabilities. KIET's program for these activities has been developed in conjunction with industry representatives, and is summarized below.

4.16 Services: KIET will provide a central capability to perform a broad range of services which in countries such as the US are provided through a large network of service companies. This central capability will reduce the initial investment requirement of companies entering these fields, and improve their operating environment. KIET's services, largely expected to be available by early 1980, include: (i) Custom Design: KIET will design ICs and small digital systems to meet specific requirements of individual companies. For example, KIET might assist a TV-game manufacturer by redesigning the existing IC to offer additional competitive options; (ii) Supply of Mask-sets, Wafers, PCBs, and Gases: KIET will perform an import-substitution function by domestically supplying mask-sets and wafers to semiconductor companies. To assist small digital systems companies, KIET will produce special printed circuit board (PCB) prototypes. Domestic supply of these critical inputs is expected to significantly reduce turnaround times, provide cost-savings, and also encourage the development of a domestic semiconductor industry. KIET will also provide special gases, which are needed for semiconductor processing, and are presently not available at required purity levels; (iii) Testing, Quality Control and Assurance: KIET will carry out electrical and environmental testing of semiconductor devices and systems hardware. These services

are presently omitted or contracted in the US and Japan at very high costs. KIET will also perform the related quality control and assurance function, which is expected to provide a major benefit by improving product quality and reliability; (iv) Equipment Services: KIET will provide industry with access to its facilities for special processing such as ion-implantation, and will incorporate and centrally offer an equipment maintenance and service capability; (v) Training: Training of industry personnel in both the semiconductor and systems areas will be one of KIET's major services. KIET will operate a training center for industry, and offer short courses, seminars and workshops supplemented by practical hands-on training. Training will be conducted by KIET staff and the foreign experts to be invited periodically by KIET (para 4.11); and (vi) Market Analysis: KIET, through its liaison office and its Project Development group, will process market information and point out export opportunities to industry. In this regard, it will also promote Korean capabilities overseas.

4.17 Product and Process Development: KIET's development activities have been defined in a tentative 4-year program which is illustrated in Annex 4-4. The program is being finalized, particularly for the systems area, and will be submitted to the Bank for review and consultation no later than June 30, 1979. The program focuses on proven product and process technologies which were selected on the basis of the following primary criteria: (i) potential to enhance competitive position in existing products through technology upgrading and local development of components that incorporate improvements made possible by semiconductor technology; (ii) potential for impact on broad segment of Korean electronics industry; (iii) relative stability of process and product technologies; (iv) relative maturity of products in their life cycle leading to demonstrated market acceptance and minimal marketing requirements; (v) size of the domestic market, import substitution and export potential; and (vi) capability of Korean industry to adapt the selected technologies.

4.18 The program aims to adapt proven advanced technologies to upgrading existing product capabilities and developing new product opportunities. More specifically, in the semiconductor area, it focuses on both product and process development for the domestic manufacture of ICs for consumer, industrial and telecommunications applications. KIET will initially work on circuits that are presently required in large volumes by Korean industry. These include circuits for clocks, audio-systems, calculators, TVs, instrumentation and control systems, and Korea's advanced telecommunication system. Of particular significance is a program to improve capabilities in the manufacture of TVs (Korea's most significant electronics export) by developing an advanced Korean color TV through an expected cooperative effort among several local manufacturers and KIET. These efforts will be supported by the development of processes for the manufacture of these circuits using linear bipolar technology. Subsequently, KIET intends to emphasize process development for digital applications, such as the fabrication of microprocessor and memory chips, using primarily the popular NMOS technology.

4.19 In the digital systems area, KIET is refining its present program to better identify opportunities for Korean industry with the assistance of

consultants financed under the UNDP project (para 3.02). Presently, KIET proposes to work initially on the development of an intelligent terminal, key-entry systems and small digital systems at specific industry request. In parallel, it will develop the required software for these applications. Also, it will emphasize the development of a manufacturing capability in two-sided printed circuit boards, which form the base of most digital systems and are presently not available domestically. Subsequently, KIET will undertake the development of controllers for peripheral devices used along with computer systems, and a Korean microcomputer.

4.20 In line with its semiconductor process development program KIET will undertake production of wafers for domestic supply, and initially also for export on a limited contractual basis (para 3.04). Production is expected to be limited to the most common linear bipolar and NMOS processes. KIET's production of mask-sets and double-sided printed circuit boards is also expected to reach a scale adequate to support domestic industry.

4.21 This development work will largely be carried out within the framework of the RD&E program, which is discussed below.

C. RD&E Program

1. Purpose

4.22 The RD&E program will assist in financing both KIET and industry-sponsored projects carried out in KIET's facilities for the development of products, processes, and systems up to the final development stage. It will not finance RD&E conducted by industry in-house. To ensure that research work is closely tied to industry goals, the major proportion (about 70%) of the research carried out in KIET's facilities will be required to have an industry sponsor, who would contribute directly to research costs. In the initial years, industry will contribute about 35% of the costs of industry-sponsored projects. The balance would be provided by KIET and recovered from industry through a system of royalties (para 4.27). Industry's contribution to RD&E costs under this risk-sharing arrangement is significantly higher than in other countries involved in such efforts. Research projects sponsored by small and medium-sized firms will receive particular emphasis by KIET, which is expected to allocate about 25% of its annual RD&E resources to this purpose and to allow more liberal cost sharing arrangements with smaller firms (para 6.11). Industry's contribution to RD&E project costs, as well as the percentage of industry-sponsored projects are expected to increase over time as KIET's success in carrying out RD&E projects is demonstrated. Commercialization, production, and sale of the final research product will be the responsibility of the industry sponsor. KIET, however, may undertake prototype production until sufficient volumes are built up for transfer to industry for large-scale production.

4.23 Detailed guidelines for KIET's RD&E operations are provided in Annex 4-5. These have been adopted by KIET's Board of Directors and discussed and agreed to with industry. KIET will review any future substantive changes in these guidelines with the Bank.

2. Organization and Administration

4.24 Identification of suitable research projects in conjunction with industry is the responsibility of KIET's management. An RD&E Review Committee will be formed, chaired by the President of KIET and composed of KIET's three operating Vice-Presidents, the Director of Project Development, and the Director of Finance. The Committee, in consultation with KIET's technical advisor and industry will, before the beginning of each fiscal year, review and approve a 4-year research program consisting of a detailed research program for the first year and an indicative program for the three subsequent years. The 4-year program will be updated and reviewed by the Committee at least quarterly. This approach is expected to ensure the coordination and integration of the research efforts of KIET's three operating divisions and provide a focus to the research efforts of KIET overall.

3. Monitoring of RD&E

4.25 Close monitoring of KIET's RD&E activities in its early years is considered necessary to ensure that proper direction is maintained. Therefore, until the Bank loan is fully disbursed, KIET will submit to the Bank annually for review: its 4-year RD&E program, including the budget, and quarterly implementation reports for monitoring purposes. These quarterly reports to be submitted to the Bank to assist in this review process are detailed in para 6.18.

4.26 The Bank will not necessarily finance all projects in KIET's RD&E program, but will select only those projects which are expected to have a broad impact on industry, and particularly those which promote a cooperative effort among firms. Bank financing of individual RD&E projects will be based on the submission of a recommendation from the RD&E Review Committee and KIET's technical advisor, a project budget and a comprehensive research proposal outlining, among other things: (i) research objectives; (ii) the rights, obligations, and financial contributions of KIET and the industry sponsor under the research contract; (iii) economic, financial and commercial merits of the project; (iv) ability of KIET to carry out the work from a technical point-of-view; and (v) ability of the sponsoring firm to bear its share of research costs and to bring the product to commercial fruition. These arrangements are detailed in Annex 4-5.

4. Recovery of Research Costs

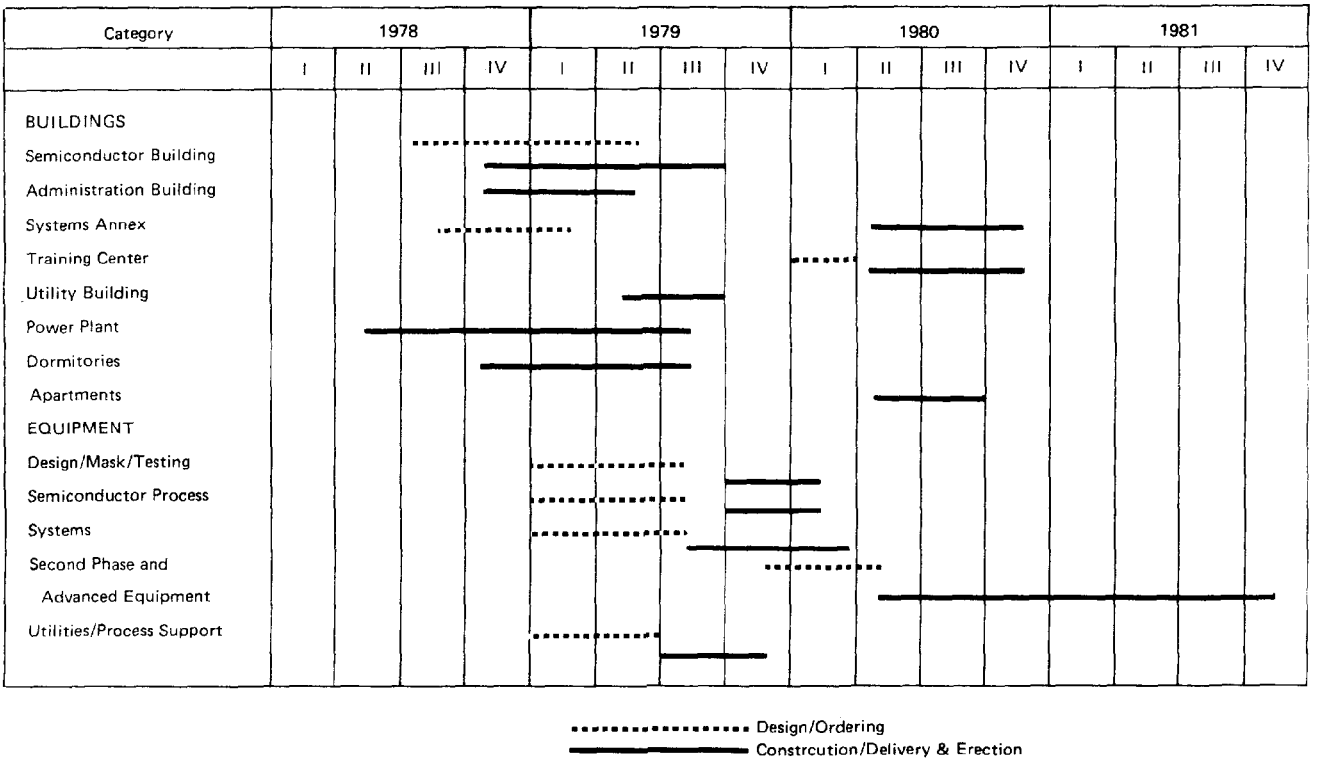
4.27 KIET's investment in research will be recovered through royalties on successful research projects. Such royalties will be set at a level sufficient to recover, in real terms, KIET's costs on both successful and unsuccessful research work. Royalty rates and the period over which royalties will be paid will be negotiated at the time of (KIET's) signing a research contract with the sponsoring firm. Depending on the type of product or process developed, royalty arrangements could take the following forms: (i) fixed fees regardless of sales volume; (ii) percentage of sales; or (iii) unit royalties based on the number of units sold.

D. Project Implementation and Management

4.28 KIET will be responsible for project execution, under the direction of its President and three Vice Presidents. Civil works will be the responsibility of a project management team, responsible to the President, which will draw on requisite capabilities in design, engineering, construction, procurement, and project finance from within its administration group. As indicated, the semiconductor building has been designed with the collaboration of an experienced architect/engineering company, which will continue to monitor construction. A semiconductor facility expert will be responsible for day-to-day supervision of construction and equipment installation (para 4.04). Equipment selection and procurement will largely be coordinated at KIET's US liaison office with the assistance of its technical advisor. Technology-related components of training, expert-invitation, and technology acquisition will be executed under the direct responsibility of the Vice Presidents, also with assistance from the liaison office and the technical advisor.

4.29 Project implementation is already underway in a number of areas. The site has been acquired and prepared, the semiconductor building shell and the power plant financed by the Government are under construction. Initial stages in the procurement of process support systems and operational equipment - advertisement, prequalification, and preparation of specifications - have been completed. KIET has also demonstrated remarkable resourcefulness in getting training programs underway. Equipment available at the KIET Semiconductor Laboratory has been supplemented to serve as a training ground for KIET staff so that a core of experienced personnel will be available to start operations as equipment is installed. UNDP funds have also been applied effectively towards overseas training. The liaison office is already functional. The schedule for further implementation of the project is shown in the following chart. Equipment will be procured in two phases (in early 1979 and in early 1980) to match KIET's manpower and workload buildup, and allow KIET to take advantage of technological changes in 1979, particularly in the rapidly changing field of sub-micron (millionths of a meter) lithography, possibly utilizing an electron-beam in place of conventional light. Mechanical completion of the project, defined as completion of all civil works and equipment installation, is expected by October 1981. As noted and as part of the project definition, technology acquisition, training and expert-invitation programs will be implemented on a continuous basis through 1981, and RD&E program activities through 1982.

Project Implementation Schedule



V. PROJECT COST AND FINANCING

A. Project Cost Summary

5.01 The total cost of the project is estimated at US$62.9 million equivalent, of which US$33.4 million is in foreign exchange. The cost estimates were developed by KIET, with the assistance of its technical advisor, and reviewed by the Bank. These are detailed in Annex 5-1 and summarized in the following table for the two components of the project--the development of KIET including physical facilities and technology-related elements; and the RD&E program.

KIET: Project Cost Estimates

	Won Millions			US$000			% of	% of Base
	Local	Foreign a/	Total	Local	Foreign a/	Total	Total	Cost
Development of KIET								
(i) Physical Facilities								
Land	710	-	710	1,460	-	1,460	2.3	2.9
Civil Works	3,490	870	4,360	7,200	1,780	8,980	14.3	17.9
Process Support Systems	800	2,600	3,400	1,650	5,360	7,010	11.2	14.0
Equipment	-	5,670	5,670	-	11,690	11,690	18.6	23.3
Erection and Installation	410	-	410	850	-	850	1.3	1.7
Taxes	160	-	160	340	-	340	0.5	0.7
Subtotal	5,570	9,140	14,710	11,500	18,830	30,330	48.2	60.5
(ii) Technology Items								
Training	50	1,000	1,050	100	2,070	2,170	3.5	4.3
Expert Invitation	100	370	470	210	770	980	1.6	2.0
Technology Acquisition	-	810	810	-	1,660	1,660	2.6	3.3
Subtotal	150	2,180	2,330	310	4,500	4,810	7.7	9.6
Physical Contingency	300	1,070	1,370	620	2,210	2,830	4.5	5.6
Price Contingency	550	910	1,460	1,130	1,880	3,010	4.8	6.0
Subtotal	850	1,980	2,830	1,750	4,090	5,840	9.3	11.6
Working Capital	2,860	480	3,340	5,880	990	6,870	10.9	13.7
Total Cost of KIET Development	9,430	13,780	23,210	19,440	28,410	47,850	76.1	95.4
RD&E Program								
RD&E Program	4,850	2,420	7,270	10,000	5,000	15,000	23.9	29.9
Total Project Cost	14,280	16,200	30,480	29,440	33,410	62,850	100.0	125.3
of which: Base Cost b/	10,570	13,740	24,310	21,810	28,330	50,140	80.1	100.0

a/ Includes indirect foreign exchange, estimated at Won 1.07 billion (US$2.2 million equivalent), around 80% of which is for civil works .

b/ Excluding contingencies and working capital.

5.02 Capital cost estimates are based on prices prevailing at end-1978, and actual contract amounts/costs for some Government-financed items which have already been contracted/expended. Equipment cost estimates include appropriate allowances for vendor training, spares, freight and insurance. The taxes shown represent a defense tax of 10% of applicable duties for equipment imports, which are expected to average 20%. KIET, however, is exempt from paying the duties themselves. The amount for expert invitation provides for 104 man-months of visiting foreign experts at an average cost of US$8,000 per man-month, including travel and subsistence expenses. A physical contingency of 10% has been provided for all expenditures which have not already been expended/contracted at fixed prices. Price escalation allowances are also provided, based on the following annual inflation rates: 10% for local cost items for 1979-81; 10% for imported process support systems and equipment for 1979-81; and 7.5% for training and expert invitation expenditures for 1979, declining to 7% for 1980-81.

5.03 Initial working capital requirements are estimated at US$5.9 million in local currency, and US$1.0 million in foreign exchange for inventories of imported materials. Projects expected to be carried out under the RD&E program between 1979-82 are estimated to required expenditures of US$15 million, a third of which is in foreign exchange. Total project cost estimates are considered reasonable.

B. Financing Plan

5.04 Project costs will be financed by Korean industry, the Government, KIET, and the proposed Bank loan as shown below:

Project Financing Plan (1977-82)
(US$ Millions)

	Local	Foreign	Total	% of Total
Development of KIET				
Korean Industry	1.4	-	1.4	2.2
Government of ROK/KIET a/	18.1	4.4 b/	22.5	35.8
IBRD Loan	-	24.0	24.0	38.2
Subtotal	19.5	28.4	47.9	76.2
RD&E Program (1979-82)				
Korean Industry	3.7	-	3.7	5.9
Government of ROK/KIET a/	6.3	-	6.3	10.0
IBRD Loan	-	5.0	5.0	7.9
Subtotal	10.0	5.0	15.0	23.8
Total	29.5	33.4	62.9	100.0

a/ KIET's contribution to project costs will arise from internally generated funds.

b/ For indirect foreign exchange (US$2.2 million) some items already expended (US$0.7 million); working capital (US$1.0 million); and contingencies (US$0.5 million) not covered by Bank loan.

5.05 Korean industry has already provided a capital contribution of US$1.4 million toward the development of KIET as shown, and has pledged an additional US$0.6 million equivalent, which would then reduce the required Government contribution by the same amount. Industry's contribution, though small in relation to total project cost, reflects a significant commitment to the objectives of the project by the companies with plans to invest in the semiconductor and systems areas. It is also unusual for private firms to contribute so much to a Government institution, which has not yet demonstrated its capabilities. Moreover the funds are being contributed in advance of the establishment of industry's own facilities in these areas. The remainder of the funds required for KIET's development will be provided by the Government, KIET's internal cash generation, and the proposed Bank loan.

5.06 Of the RD&E program, 70% of the projects are assumed to be sponsored by industry, and the remainder by KIET. The financing of the program is designed to encourage industry to engage in RD&E. Industry will be required to finance US$3.7 million equivalent, or around 35% of the cost of RD&E projects sponsored by it. The remainder of the cost of industry-sponsored projects (US$6.8 million) and KIET-sponsored projects (US$4.5 million) will be financed by the Government, KIET's internal cash generation, and the Bank loan, which would cover US$5 million in foreign exchange expenditures. As RD&E results are obtained and commercialized, royalties from industry are expected to enable KIET to recover its share of project costs (para 4.27). KIET will then continuously reinvest these funds in new RD&E projects.

5.07 In line with the Government's policy for establishing such institutes, Government funds to KIET will be passed on as grants through budgetary allocations; the Government has agreed to provide adequate allocations to meet project expenditures, including any cost overrun. The proposed Bank loan of US$29 million will be provided to the Government for 15 years including 4 years grace. The Government has agreed to channel the loan to KIET in accordance with its practice for passing-on the proceeds of Public loans to Government agencies. The proceeds of the Bank loan will be made available to KIET on the same terms and conditions as the Bank loan to the Government, with automatic corresponding budgetary allocations to KIET to cover its debt service obligations under these terms. In practice, therefore, no debt service obligations will be imposed on KIET.

5.08 The provision of funds in this form is justified in view of KIET's nature as an institution providing infrastructural support and vital services to industry, as well as its objective of promoting development in a high risk area. Such direct support is in line with the experience and practice in both developed and developing countries. Research institutes normally require at least 7-10 years to become financially self-sustaining. Under present arrangements, which combine services and RD&E, KIET is expected to become financially self-sustaining in only about four years after start-up, and not require further support for operations from the Government. This financial self-sufficiency is essential to preserve the basic character of KIET, which emphasizes services to, and for the benefit of, the industry. If KIET were subject to

continuous financial pressure, as might arise if debt service obligations were imposed on it, it might be forced to utilize its production equipment to undertake production activities and thus forego its prime objectives of developing new technologies and providing services for the industry. This would be particularly detrimental to the development of small and medium-sized firms, which will have to rely on KIET for the bulk of their technological requirements.

5.09 Nevertheless, to reflect the cost of the Bank loan, KIET will, in costing its services, apply a notional interest of 10% per annum on the portion of Bank funds used in providing such services (para 6.06).

5.10 In order to meet foreign exchange expenditures not covered by the Bank loan and those for which KIET would disburse directly and only thereafter seek reimbursement from the Bank, the Government has agreed to provide KIET with the required foreign exchange or permit KIET to convert local funds to foreign exchange as necessary. The Government also will provide an advance of US$500,000 equivalent (US$250,000 by June 30, 1979 and US$250,000 in January 1980) in order to enable KIET to pay for Bank-financed items prior to seeking reimbursement from the Bank.

C. Items to be Financed by the Bank Loan

5.11 The Bank loan will be used for financing 100% of the foreign exchange expenditures for process support systems, equipment, training, expert invitation, and technology-acquisition (excluding US$700,000 already paid by the Government), and associated contingencies. It will also be used for 100% of the foreign exchange expenditures for selected subprojects under the RD&E Program between 1979 and 1982 up to US$5.0 million. Details are provided in Annex 5-2, and summarized below.

Allocation of Bank Funds
(US$ Millions)

Development of KIET	Amount of 100% Foreign Exchange Expenditures a/
1. Physical Facilities	
Process support systems	4.9
Equipment	12.8
2. Technology-related items	4.4
Sub-total	22.1
RD&E Program	5.0
Contingencies b/	1.9
Total	29.0

a/ For limited qualification, please see para. 5.12 below.

b/ Physical contingencies only; price contingencies are included in relevant categories.

D. Procurement

5.12 In the process support systems and equipment category (US$17.7 million), packages over US$100,000 in value will be procured through international competitive bidding in accordance with Bank guidelines (over 65% of the packages are expected to fall in this group). Proprietary items not exceeding US$2 million in aggregate are expected to be procured through negotiation; the remaining small packages in this category will be procured through limited international tendering with Bank approval of the list of items to be so procured. Technology-related items (US$4.4 million) will be arranged through negotiation with selected sources from within the annual programs reviewed by the Bank (paras 4.13 and 6.17). For the RD&E program items (US$5 million), in view of the necessity for KIET to act quickly in executing RD&E subprojects, the low cost of most individual items, and their specialized and often proprietary nature, most procurement will follow limited international tendering procedures. As per present capabilities, Korean suppliers are not expected to compete for Bank-financed items. Nevertheless, if they are judged qualified to compete based on future developments, a 15% preference on equipment supply would be provided to them in accordance with Bank guidelines. Other items including civil works, which will be financed by the Government and industry, will be procured in accordance with Government procurement procedures, which are satisfactory.

E. Disbursement

5.13 Bank funds will be disbursed against 100% of the foreign exchange expenditures (or 100% of the ex-factory price if a package is awarded to a local supplier after international competitive bidding) for goods and services to be financed by the Bank. For small items related to training, expert invitation, technology acquisition, and the RD&E program, KIET will be required to disburse directly and seek reimbursement from the Bank against accumulated expenditures on a quarterly basis. For this purpose, KIET will use the US$500,000 Government advance (para 5.10). Disbursement for process support systems and equipment will be based on submission of documents in accordance with the Bank's standard requirements. For expenditures under the training, expert-invitation, technology-acquisition and RD&E programs, disbursement will be based on the prior Bank approval of the relevant program and RD&E subprojects, and submission of contracts/agreements and invoices (also evidence of payment where reimbursement is requested).

5.14 The amount allocated for process support systems (US$4.9 million) is expected to be disbursed by mid-1980. The amount allocated for equipment (US$12.8 million) is expected to be disbursed fully by mid-1981. Training and technology related items (US$4.4 million) are expected to be disbursed by early 1982 and RD&E program expenditures (US$5.0 million) by the end of 1982. An estimated disbursement schedule is provided in Annex 5-3.

VI. FINANCIAL ANALYSIS

A. Introduction

6.01 The prime objective of institutes engaged in RD&E is to stimulate and support technological development and not to be financially renumerative. Indeed, the vast majority of research institutes in both developed and developing countries rely on continuous Government support to finance their capital and operating requirements. This is particularly true in developing countries, where the industry does not have the capability to carry out its own RD&E activities. Although financial return is not a relevant measure of performance (para 6.18), financial analysis of KIET is necessary not only to determine the amount and terms of resources required, but also to assist in determining the most appropriate orientation of the institute.

6.02 In this regard, KIET has been structured so that its RD&E operations will be supported to a large extent by revenues from its service activities (paras 6.12 and 6.13). The distinction between the two, however, is somewhat blurred since in the semiconductor industry, most of the research and development is carried out continuously on the production line, where improvement in yields, once a product or process has been developed, is the most important determinant of competitiveness. The importance of this is confirmed in a recent study on the sale and purchase of semiconductor know-how worldwide. 1/

1/ Sale and Purchase of Semiconductor Know-how, ICE, October 1978.

This study shows that generally about 90% of the price paid for purchased technology is for services such as training (15-20%), start up assistance (10%), yield guarantees (15%), and, most significantly, long term product and process development support (45-50%). KIET will be providing this type of assistance to industry through its service operations where KIET will assume production of wafers, masks, etc. in order to improve process yields to satisfactory levels so that production may then be transferred to industry. In this sense, much of KIET's service activities represent, in fact, ongoing RD&E on the production line for the benefit of industry.

6.03 KIET's major emphasis in the initial years of operation (1980-82) will be on providing the development and support services that are necessary to help industry acquire design, process and manufacturing know-how. As industry acquires basic capabilities, an increasing share of KIET's resources will go into process and product development and engineering. By 1987, for example, it is expected that about 40% of KIET's manpower will be devoted to RD&E activities, compared to 30% in 1982.

6.04 For the purpose of preparing financial statements, KIET's activities have been divided into their two main components -- services and RD&E. Major assumptions for revenues and costs in these areas are presented in Annexes 6-1 to 6-3. Projected income statements for KIET's service operations are given in Annex 6-4. For RD&E, expenditures are treated as an investment to be recovered over time in the form of royalties. This is shown in the projected sources and application of funds for RD&E operations in Annex 6-5. These statements provide the basis for the consolidated (services and RD&E) sources and application of funds (Annex 6-6) and balance sheets (Annex 6-7). Projections are prepared in current terms for 1978-87.

B. Service Operations: Revenues and Costs

6.05 Revenues from KIET's major services (wafers, masks, IC design, testing, and systems) are derived from the assessment of the local requirements for these items contained in Annex 6-1. Export revenues may arise in the few cases where, as a means of acquiring technology, contract production is undertaken for foreign firms directly by KIET, rather than by the ultimate recipients of such technology, i.e. Korean electronics firms. These revenues are, however, expected to be small and uncertain and have not been included in the projections. During 1979, revenues will be confined to those which can be generated from the existing head office in Seoul. Initial operation at Gumi is expected to commence in January 1980, with revenues increasing thereafter to a steady state level in 1982.

6.06 Assumptions for prices and costs are detailed in Annex 6-2. They are based on KIET's service pricing policy (Annex 6-3) which has been adopted by KIET's Board of Directors. This policy emphasizes KIET's role as an organization designed to stimulate the development of the industry while, at the same time, recognizing the desirability, to the extent consistent with that objective, of recovering the cost of carrying these service operations and generate from December 31, 1983 onwards funds sufficient to cover both its cash deficit from its RD&E operations and the funds required to maintain and develop its technological capabilities consistent with the industry's needs. For the purpose of costing KIET's services, a notional interest of 10% will be applied to the portion of World Bank funds used in providing such services. In

view of the competitive nature of the electronics industry worldwide, the prices for KIET's services are expected to be set in line with prices for such services elsewhere so as not to place at a disadvantage an industry which is still at a very early stage of development. This is not only important to attract domestic and joint venture investment in this sector but also vital for the small and medium sized firms which will have to rely on KIET for the bulk of their basic technological and technical needs. These prices are on average sufficiently high to cover total production costs, including the notional interest on the Bank funds used in providing such services. Any changes in this pricing policy will be made in consultation with the Bank.

6.07 As shown by the summarized income statements, KIET is expected to operate at a loss until steady state operations are achieved in 1982. This reflects both heavy fixed costs, such as depreciation and administrative expenses, and the fact that about one-third of KIET's facilities will be utilized by RD&E projects for the benefit of industry and will thus not be available for revenue earning activities. Moreover, the advantages of lower wage and engineering costs in Korea are expected to be offset by lower yields attributable to the nature of KIET's on-going process and product development work (para 6.02).

KIET: Summarized Income Statements (Services)
(Won Millions)

	1979	1980	1981	1982	1984	1987
Service Revenues						
Wafers	-	1,673	4,220	7,421	8,979	11,946
Masks	68	330	461	582	704	937
IC Design	49	206	550	606	733	975
Testing	49	310	577	631	764	1,016
Systems	339	560	822	905	1,095	1,457
Other	49	454	945	1,040	1,259	1,675
Total Revenues	554	3,533	7,575	11,185	13,534	18,006
Net Income (Loss) a/	(892)	(1,313)	(695)	53	589	1,953
Cash Generation b/	(613)	22	1,090	1,972	2,581	3,925

a/ As a Government Institute, KIET does not pay income taxes. Accordingly, these have not been included in the net income calculation.
b/ This will largely be absorbed by deficits on RD&E operations and on-going capital expenditures (para 6.14)

6.08 The largest component in KIET's revenues comes from wafer services. Initially, about 70% of wafer services will be for process and product development that would be transferred to industry upon completion of development work. This percentage is expected to decline to about 40-50% by 1987 as industry develops its own process and engineering capabilities. The remaining wafer supply will consist of wafers required by the smaller firms which cannot obtain their relatively small requirements at competitive prices elsewhere. KIET will supply these wafers by pooling and standardizing the industry's

requirements and will produce them until the volume grows to the level that would attract commercial production. An important distinction between KIET and industry wafer activities is that KIET will concentrate on product and processes that are beyond the industry's capabilities, and it will only be engaged in small volume production until the product and process development is sufficiently advanced to be transferred to industry. Thereafter, KIET will act as trouble shooter to solve industry production problems and will support it continuously in increasing yields.

C. RD&E Operations: Revenues and Costs

6.09 RD&E revenues consist of royalties and small inflows (about 5% of annual royalties) from the sale of specialized equipment on the completion of the RD&E projects for which such equipment was purchased. Royalties are planned to be set at a level sufficient to recover in aggregate (in real terms) KIET's costs on both successful and unsuccessful research work. For projection purposes, royalties are calculated in equal installments over 5 years to return to KIET the cost of research expended in any particular year plus an allowance for inflation of 10% annually.

6.10 Annual RD&E expenses (manpower, materials, equipment, training, technology purchase, and overheads) are based on cost estimates for representative RD&E projects which KIET is likely to undertake over the 1979-82 period. Annual research expenditures in current terms are forecast to increase from about US$1.5 million in 1979 to US$6.0 million in 1982 and to US$15.5 million by 1987.

6.11 KIET will bear 100% of the cost of RD&E projects sponsored solely by it (about 30% of the total). On industry sponsored projects (70% of the total), cost sharing between KIET and industry is expected to be done on a 65:35 basis respectively, with industry participation likely to increase over time as KIET's effectiveness in carrying out RD&E is demonstrated. These assumptions are realistic and have been confirmed in discussions with industry leaders in Korea. As already mentioned in para 4.22 and detailed in Annex 4-5, Section 9, KIET will endeavor to allocate at least 25% of its annual RD&E expenditures to small and medium sized enterprises, and will foster small scale companies in a variety of ways, such as through more lenient cost sharing arrangements for research expenditures and royalty payments.

6.12 Because of the increasing level of RD&E expenditures over time, and the lag between these and the receipt of royalty revenues, KIET's RD&E activities are expected to operate at a deficit over the 1979-87 forecast period. In the initial years, 1979-82, deficits will be covered by Bank funds, provided as part of the project, for research expenditures in foreign exchange, and by Government funding. This is shown in the summarized sources and applications of funds for RD&E in the following table:

Summarized Source and Application of Funds (RD&E)
(Won Millions)

	1979	1980	1981	1982	1984	1987
Sources						
RD&E Revenues	-	121	424	837	2,119	4,370
Contributions						
ROK	326	533	567	-	-	-
IBRD	242	485	728	970	-	-
Total Contributions	568	1,018	1,295	970	-	-
Total Sources	568	1,139	1,719	1,807	2,119	4,370
Applications						
RD&E Expenditures a/	728	1,455	2,184	2,911	4,260	7,545
Less Industry Share	178	356	535	713	1,044	1,849
	550	1,099	1,649	2,198	3,216	5,696
Increase in RD&E Work Cap.	18	40	70	88	140	170
Total Applications	568	1,139	1,719	2,286	3,356	5,866
Deficit to be met from KIET's Service Operations	-	-	-	(479)	(1,237)	(1,496)

a/ Including small amounts of fixed assets purchased for RD&E projects.

It is however expected that, beginning in 1982, additional Government contributions to KIET's overall operations will not be required, since cash generation from KIET's service activities should be adequate to cover RD&E deficits; this is further discussed below.

D. Overall Funding of KIET and Financial Position

6.13 During the initial period of operations, 1979-82, Bank funds, for the development of KIET and the RD&E program (para 5.05), as well as Government funding will be required to meet the gap between KIET's operating, RD&E and capital expenditures, and its revenues. Thereafter, KIET's operations are expected to become financially self-sustaining on an overall basis. Nevertheless, the Government has agreed to meet, on a timely basis and at all times, KIET's annual funds requirements, including necessary foreign exchange, for operations, RD&E, working capital and capital expenditures to the extent that these are not covered by KIET's internal cash flow.

KIET: Summarized Sources and Applications of Funds
(Services and RD&E)
(Won Millions)

	1979	1980	1981	1982	1984	1987
Sources						
Funds from Service Operations	(613)	22	1,090	1,972	2,581	3,925
Funds from RD&E Operations	-	121	424	837	2,119	4,370
Contributions						
ROK	3,402	4,176	1,290	-	-	-
IBRD	6,445	4,141	2,508	970	-	-
Total Contributions	9,847	8,317	3,798	970		
Total Sources	9,234	8,460	5,312	3,779	4,700	8,295
Applications						
Capital Expenditures	9,722	6,483	2,458	-	1,455	1,936
RD&E Expenditures a/	550	1,099	1,649	2,198	3,216	5,696
Increase in Working Capital b/	(1,038)	878	1,205	1,049	480	625
Total Applications	9,234	8,460	5,312	3,247	5,151	8,257
Surplus Cash	-	-	-	532	(451)	38
Accumulated Surplus Cash	-	-	-	532	655	410

a/ Including small amounts of fixed assets purchased for RD&E projects.
b/ Working capital declines in 1979 as 1978 cash balances are utilized for project construction.

KIET: Summarized Balance Sheets (Services and RD&E)
(Won Millions)

	1979	1980	1981	1982	1984	1987
Current Assets	369	1,643	3,329	4,779	6,047	8,514
Surplus Cash	-	-	-	532	655	410
Fixed Assets	10,634	15,781	16,454	14,535	12,080	11,767
Investment in RD&E	550	1,528	2,753	4,114	6,465	9,996
Total Assets	11,553	18,952	22,536	23,960	25,247	30,687
Current Liabilities	167	563	1,044	1,445	1,809	2,566
Capital - Contributions	12,870	21,187	24,985	25,955	25,955	25,955
- Retained Earnings	(1,484)	(2,798)	(3,493)	(3,440)	(2,517)	2,166
Total Liabilities & Capital	11,553	18,952	22,536	23,960	25,247	30,687

6.14 As can be seen from the projected sources and applications of funds and balance sheets for KIET as a whole, which are summarized in the preceding tables from Annexes 6-5 and 6-6, KIET's surplus cash build-up through 1982 will be very small. Subsequently, it is estimated that beginning in 1984, KIET will be required to spend in excess of US$3.0 million annually for new equipment to enable it to keep pace with technological developments in the industry. This, together with the cash drain created by RD&E operations, will act as a further limitation on surplus cash generation and underlines the necessity to relieve KIET from annual debt service commitments on Government as well as Bank funds for the project (para 5.08).

E. Financial Covenants

6.15 In order to ensure the maintenance of a sound financial position, once project operations begin in 1980, KIET will maintain a current ratio of at least 3.0. Further, until the end of 1983, KIET will not undertake any investments, other than for the project, exceeding US$2 million in any one year, including investments for fixed assets under the RD&E program, without prior consent of the Bank.

6.16 Under the supervision of its financial director, KIET will prepare by September 30, 1979 a cost accounting system to determine the allocation of KIET's direct and indirect costs of its services and RD&E activities, including an evaluation of the implications of such on its RD&E operating and service pricing policies. This system will be reviewed by the Bank and implemented by KIET by December 31, 1979.

F. Auditing and Reporting Requirements

6.17 KIET is presently audited by Oju Audit Corporation, the fifth largest auditing firm in Korea and the Korean representative of the international firm of Peat, Marwick, Mitchell. The Corporation is approved by the Ministry of Finance to perform audits of Government institutes, and publicly-owned corporations traded on the Korean Stock Exchange, and is satisfactory to the Bank. KIET will submit annual audit reports to the Bank within four months of the end of each fiscal year as well as quarterly financial statements and project progress and procurement status reports within 45 days of each quarter.

6.18 In addition to the above, KIET will submit to the Bank a number of other reports covering key areas of its operations. For RD&E, in addition to the annual four-year research program (para 4.25), quarterly reports will be submitted to the Bank as follows: (i) a brief evaluation of the outcome of research projects completed in the quarter; (ii) a summary of the progress of on-going projects; (iii) an outline of new projects approved; (iv) a statement showing actual costs to date, original budgeted costs, and estimated costs to complete for the research program overall, and for individual projects where these have been financed by the Bank. Second, until the Bank loan is fully disbursed, KIET will: submit to the Bank, for review and approval, an annual training and expert-invitation program (para 4.13) together with the recommendations in these areas of its technical advisor; and to consult with the Bank on its annual technology acquisition and capital expenditure program. Finally,

after completion of the project, KIET will prepare and furnish to the Bank a comprehensive report on the project, its implementation, initial operation, and the costs and benefits derived and expected to be derived thereon.

G. Sensitivity Analysis

6.19 The main financial issue facing KIET is the question of the amount of funding, over and above internal cash flows, which will be required to sustain its service and RD&E activities. While the Government will meet any cash deficits which may arise from KIET's service and RD&E operations (para 6.13), sensitivity tests have been performed on KIET's funds flows to assess the impact of changes in capital costs, operating costs, and revenues as shown in the table below.

Sensitivity Tests on Increases (Decreases) of Total Funding Requirements for KIET [a/]

	1979-82	1983-87
	(Won Millions)	
Increase in Capital Costs by 10%	1,987	675
Decrease in Service Revenues by 10%	2,022	6,187
Increase in Operating Costs by 10%	2,083	6,235
Decrease in RD&E Royalty Revenues by 25%	315	3,384
Increase in RD&E Royalty Revenues by 25%	(315)	(3,384)

a/ As compared to Base case funding.

6.20 These figures clearly show that should revenues decrease or operating costs increase, KIET will require continued Government financial support beyond 1982 as compared to the financial self-sufficiency of KIET projected in the Base case. These changes in revenues and costs need not reflect lower performance, but could result from a change in the mix and nature of services and RD&E operations that are necessitated by the electronics industry growth pattern. This uncertainty, which is inherent in a rapidly growing and changing electronics industry, underlines the need for an annual review by Government of KIET's financial position to ensure that KIET not only has adequate resources to undertake the optimum mix of services and RD&E, but also has the capabilities to maintain KIET's technological leadership in the Korean electronics industry.

H. Major Risks

6.21 The major risks faced by the project are technological and managerial. First, the substantial amounts of funds and effort being spent by industry and Government in advanced countries to remain competitive in the electronics industry can be expected to lead to continued rapid technological change. Such change could substantially curtail the useful life of processes

and technologies acquired by KIET. This is an ever present risk in the industry, and one which KIET, like others in the field, must face continuously. KIET's planned focus on a limited number of relatively mature technologies and their application to upgrading existing product capabilities, which is the strategy followed by a number of consumer electronics companies, is expected to alleviate the risk significantly. KIET will be less vulnerable to this risk of "backing the wrong horse" than semi-conductor industry leaders who are engaged in developing new products and processes at the cutting edge of technology. Further, despite the limited number of technologies that KIET plans to pursue, these are the dominant technologies (presently accounting for over half the world's IC consumption), and adequately cover the present needs of Korea's electronics industry. Their acquisition is expected to go a long way towards establishing a domestic technological base for development in the eighties.

6.22 Second, KIET may be unable to attract the talents and obtain the capabilities required to absorb and adapt complex technologies. To counter this risk, the project provides for extensive recruitment, local and overseas training, technology purchase agreements, inputs from foreign technical experts, and installation of sophisticated equipment which increasingly incorporates a large proportion of the required technology. KIET has thus far not encountered any difficulty in attracting qualified Korean staff, locally and from abroad; also, the other inputs are readily available from a number of sources, and in view of the extensive cooperation received by KIET, from within Korea and abroad, few problems are anticipated. In the long run, however, there is a risk that KIET may be unable to attract and retain the necessary high calibre managerial and technical staff. Though KIET's present compensation structure is roughly comparable to that in industry, as a Government institution, its compensation could be eroded relative to the rapidly rising pay scales in industry. While modest turnover is desirable to accelerate technology diffusion, a high turnover, particularly in KIET's core staff could jeopardize the project. Accordingly, the Government has agreed to review KIET's compensation structure from time to time to maintain competitiveness, and to allow KIET to introduce an incentive system to motivate and reward performance (para 4.14).

6.23 Third, there is the potential risk of lack of suitable focus in KIET's RD&E activities. This could result from either spreading its resources over a large number of relatively insignificant and unrelated projects with little impact on the industry, or on a few large projects which might stretch its own and industry's capabilities unduly; both possibilities would lead to a low probability of commercial success. This risk, however, is considerably lower in the case of KIET than in a conventional isolated research institute, in view of KIET's close links with industry and the fact that a major proportion of its RD&E is required to have an industry sponsor (who will share the cost of research with KIET). To further reduce this risk and assure proper focus and balance, detailed guidelines for RD&E operations (Annex 4-5) have been jointly prepared and agreed to by industry and KIET. As part of these guidelines, KIET will each year prepare an indicative 4-year work program for Bank review and consultation, and as an additional guide to the direction of

KIET's operations, Bank financing will emphasize RD&E projects which impact a large segment of the industry and promote cooperative arrangements among Korean firms. The selected projects will also be reviewed by KIET's technical advisor to ensure that the research goals are realistic and within KIET's and the sponsoring firms' capabilities. Finally, to supplement its manpower resources, KIET will, as necessary, use foreign training and employ experts to achieve RD&E results efficiently, and thereafter work closely with industry in the transfer and commercialization stages of technology, processes and products.

6.24 Despite all the above provisions, the risk inherent in this complex project operating in a rapidly changing technological environment is higher than that in projects in most other industries. But the potential benefits of the project and at the same time the potential cost of inaction in the two critical areas of electronics -- i.e. semiconductors and digital systems which are now widely acknowledged as becoming the technologies of the future-- considerably outweigh this risk. Like other countries, Korea has concluded that the creation of a domestic technological capability in these two areas is an essential prerequisite to the further growth and development of its electronics industry. Both the Government and local industry strongly support the project. Local firms in the industry already have well defined plans for commencement of semiconductor manufacture, and recognize that their ability to obtain needed technologies and to rapidly achieve satisfactory volumes and productivity levels will to a considerable degree depend on the effectiveness of KIET in assisting them with the necessary services and RD&E support. In addition, a number of foreign firms are considering setting up joint venture operations in Korea and KIET's role as a service facility to industry will act as a catalyst to further foreign investment in this field.

VII. ECONOMIC ANALYSIS

7.01 As discussed earlier, Korea's impressive record of economic growth over the past decade has been led by rapid increases in output and exports by the manufacturing sector. In recent years, however, Korea has been facing increasing competition from other, lower-wage, developing countries where production of relatively low technology manufactures is becoming more economic than in Korea. A major focal point of the Fourth Five Year Plan is, therefore, to shift investment and growth towards more skill-intensive products such as: metals, chemicals, machinery and electronics, which take advantage of Korea's relative endowments of skilled labor and trained engineers.

7.02 Within the electronics industry, rapid technological development is progressively replacing labor-intensive assembly operations (on which much of Korea's present output is based) with LSI circuits. Many of these devices represent relatively mature technologies which can be adopted by countries such as Korea where skilled labor and engineering costs are relatively low. Indeed, if Korea is to continue to effectively compete in electronics production a significant and focused effort to develop a technological base in the semiconductor and systems areas will be required. KIET will be the lead

effort in this endeavor and will provide the infrastructure and services support on which the development of the industry will depend. Through its RD&E activities, KIET will also help create an environment conducive to productive risk taking by industry in the area of ongoing technology development.

7.03 The economic rate of return for the project's direct revenues and costs, like the financial rate of return, provides only a partial measure of its wide ranging benefits and is necessarily low, since KIET's primary objective is not to be a financial success, other than from the point of view of reasonably balancing its revenues and expenses. Instead, the success of KIET will be measured by its impact on building up a local semiconductor and systems industry and the effect this will have on reducing costs and improving the quality and reliability of the products produced by the electronics industry generally.

7.04 Between 1977-82, local production of semi-conductors for domestic use is forecast to increase from US$16 to 210 million per year (Annex 6-1) and that of systems from US$5 to 50 million. Production in these two areas is expected to further increase to US$600-800 million by 1987. Less than 10% of this increase (the benefits of which are measured in terms of Korea's estimated comparative advantage in production costs after returns to all factors of production, including capital, are considered) would have to be attributed to the project in order to yield an economic rate of return of 15%. This estimate is conservative since the services provided by KIET will act as a major catalyst in attracting new firms to enter the semiconductor and systems industries in Korea. Indeed, without the project, it is unlikely that any more than half the projected increase in industry production could, in fact, be achieved.

7.05 Assuming that such is the case, the foreign exchange savings implied by the increase in industry production of semiconductors and systems attributable to the project is estimated to be about US$50 million annually by 1982 (in real 1978 prices). This is about fourfold the US$13 million in estimated direct foreign exchange savings from the project itself by 1982.

7.06 In addition, the impact of the development in the semiconductor field on the competitiveness of the electronics industry and its capability to reach the ambitious growth targets under the Fourth Five Year Plan is likely to be considerably larger than the above figures. If we conservatively assume that the increase in semiconductor content will reduce electronics product costs by 2-3%, the net savings to Korea would be of the order of US$60 million annually by 1982 (in real 1978 prices). The impact would be even greater, if the effect of expected improvements in product reliability on market growth were taken into account.

7.07 Direct employment generated by the project would amount to about 700 persons in the 1982 steady state. The indirect employment effect of KIET, through the attraction of new firms to the semiconductor and systems estate at Gumi, assuming that without KIET only one half of the projected increase in new firms could be achieved, is expected to reach 3,000 by 1982. Even greater will be KIET's impact on sustaining the future growth of Korea's

electronics industry, where current employment is in excess of 140,000 persons. While some of this additional employment may eventually be counterbalanced by increased labor productivities in other fields of the economy, as noted previously recent studies suggest that the overall employment effect will still be positive (para 2.03). In the case of Korea, most of the growth in electronics will be concentrated in the manufacture of components, consumer products and telecommunications equipment, and will not extend into areas that could lead to labor displacement in other fields of the economy.

7.08 Finally, KIET will play an important regional role by promoting the growth of the semiconductor and systems industries in Gumi. The project location thus contributes to the Government's goal of more balanced regional development and relieving population pressures in the major urban centers.

VIII. AGREEMENTS

8.01 The following agreements were reached:

A. With the Government that it will:

(i) develop with KIET suitable procedures to permit KIET's US liaison office to procure goods and services quickly and efficiently (para 3.10);

(ii) provide physical infrastructure facilities for the Gumi semi-conductor-systems estate (para 4.07);

(iii) review KIET's compensation structure from time to time to maintain competitiveness with industry, and allow KIET to set up an employee incentive system (para 4.14);

(iv) provide KIET with sufficient annual grants to meet project expenditures, including overruns (para 5.07);

(v) bear debt service costs on the Bank funds channeled to KIET (para 5.07);

(vi) provide KIET with foreign exchange as necessary to meet project expenditures (para 5.10);

(vii) provide KIET with a US$500,000 advance to pay for Bank financed items prior to seeking reimbursement (para 5.10);

(viii) meet KIET's annual operating, working capital and capital expenditure requirements (para 6.13); and

B. With KIET that it will:

(i) retain a technical advisor (para 3.08);

(ii) establish a separate financial department (para. 3.09);

(iii) not deviate from agreed facility designs (para 4.04);

(iv) appoint and retain a semiconductor facility expert until one year after start-up of the semiconductor building (para 4.04).

(v) not undertake any investment exceeding US$2 million annually (paras 4.09 and 6.15);

(vi) comply with environmental designs and standards (para 4.10);

(vii) submit an annual technology acquisition program for review by the Bank and consultation, and meet other reporting requirements (paras 4.13 and 6.18);

(viii) set up an employee incentive system (para 4.14);

(ix) finalize its initial 4-year RD&E program, and submit it to the Bank for review and consultation by June 30, 1979 (para 4.17);

(x) review any substantive changes in RD&E guidelines with the Bank (para 4.23);

(xi) until the Bank loan is fully disbursed submit annually to the Bank for its review KIET's 4-year RD&E programs, and quarterly reports on actual implementation (para 4.25);

(xii) agree on criteria for selection of RD&E projects for Bank financing (para 4.26);

(xiii) review with the Bank any substantive changes in its Pricing Policy, which inter alia stipulates that in costing its services KIET will apply a notional cost (10% interest) on that portion of the Bank loan that is applicable to such service activities (para 5.09 and 6.06);

(xiv) maintain a current ratio of at least 3.0 (para 6.15);

(xv) develop an appropriate cost accounting system (para 6.16);

(xvi) submit annual audit reports and quarterly financial and progress reports (paras 6.17 and 6.18); and

(xvii) prepare a comprehensive completion report after project completion (para 6.18).

8.02 With the above mentioned agreements, the project provides a sound basis for a Bank loan of US$29 million to the Government of Korea for 15 years including 4 years of grace to be channeled to KIET with the debt service obligations to be borne by the Government.

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KOREA

ELECTRONICS TECHNOLOGY PROJECT

GLOSSARY OF TECHNICAL TERMS

TERM	DEFINITION	PRINCIPAL USE/FUNCTION
Chip (Also Dice, Bar or Pellet)	A piece of semiconductor material, usually a section of a silicon wafer, upon which a component or an integrated circuit is is fabricated.	The base circuit, which is then packaged through lead wires etc. into a functioning device; usually 3 mm x 3 mm. The operation of a simple calculator, for example, is based on the use of a single chip assembled and packaged with keys, displays, etc.
Compiler	A program that prepares machine language program from a computer program written in a higher-level language.	Used to enable computer users to program in computer languages such as FORTRAN, BASIC and be able to communicate with the computer, which is programmed in a different language.
Diffusion	Diffusion in integrated circuits refers to solid-state diffusion. It is a process by means of which diffusants are caused to enter a regular crystalline structure in controlled quantities. Their presence tends to change the semiconductor material's electrical characteristics. Solid-state diffusions are characteristically conducted at relatively high temperatures under extremely carefully controlled conditions.	One of the basic processes by means of which a wafer is fabricated, i.e. circuit properties introduced into base material.
Discrete Circuits	Electronic circuits built of separate, individually manufactured, tested, and asembled diodes, resistors, transistors, capacitors, and other specific electronic components.	Discretes substitute for conventional non-semiconductor components and perform basic electrical functions such as switching, regulating current and voltage, and storing charge.
DI Water	Water from which ions and minerals have been removed.	Used to clean wafers; ions are removed to avoid possible reactions.
Digital Systems	Systems based on digital operation, i.e. where operation is constrained between two levels 0 and 1.	In the report, the term is used to describe an entire segment of the electronics industry which is premised on digital systems and includes computers, minicomputers, microprocessors and their applications, and supporting software.
Electron Beam Lithrography	A recent advance in photolithography and wafer-fabrication technology which permits fabrication of sub-micron (millionth of a meter) circuit dimensions by using an electron-beam (which has an extremely low wage-lenth) to replace conventional light (with a much longer wave-length).	Increasingly being used to fabricate advanced computer memories, potentially the 64K Random Access Memory (RAM), where small circuit dimensions are essential to achieve required miniaturization.
Etch	A chemical process of dissolving material.	One of the stages in wafer fabrication.
Selective Etching	Etching which is done so that certain material is dissolved, but other materials are not affected by the etchant.	

TERM	DEFINITION	PRINCIPAL USE/FUNCTION
Integrated Circuit (IC)	The term "integrated circuit" has been applied both to a class of very small circuit structures and to a specific circuit structure (monolithic).	An IC is the base element in most electronics equipment. A TV, for example, might contain 4-6 ICs to perform various functions. A microprocessor can be, and normally is a single IC.
Digital	An integrated circuit in which the operation is constrained between two levels. The "0" and "I" levels.	Used in timekeeping, computing instrumentation (digital readouts) and frequency control.
Linear	An integrated circuit capable of performing a linear function.	Most commonly used for amplification of electrical signals, such as in radios.
Monolithic	An electronic circuit fabricated in one piece of material (it may contain numerous electronic elements such as resistors and transistors, etc.).	Another term to describe an ID fabricated on a single price of material as distinct from hybrids, where more than one material might be used.
Ion	An atom that has lost an electron from its outer valance bond.	
Ion Implantation	A method of doping or modifying the characteristics of semiconductor material by bombardment with charged particles to enhance or change the characteristics of semiconductor material from P- and N-type characteristics.	A step in the fabrication of wafers.
Large-Scale Integration (LSI)	A form of integrated circuit containing a large number of logic elements on one chip frequently requiring several layers for metallization. It is higher in complexity than Medium-Scale Integration by a factor of 10.	Used to fabricate complex circuits on a small scale, such as advanced memories on a 3 mm x 3 mm chip.
Linear Bipolar	The dominant process in the fabrication of non-digital circuits.	This technology has found wide application in consumer applications such as audio-and video-systems. It accounts for over 20% of worldwide integrated circuit consumption.
Linear Circuit	A circuit whose output is an amplified version of its input or whose output is a predetermined variation of its input.	Most commonly used for amplification of electrical signals, such as in radios.
Mask	Usually a glass plate in the photographically produced pattern used to control the location of material deposited or removed during a wafer fabrication process.	Used as the "master" in the wafer fabrication process, much as a negative in photographic development.
Metal-Oxide-Silicon (MOS)	Metal-oxide-silicon devices employ a structure which is composed of a metal layer usually deposited over a silicon dioxide layer which is used to control the conductivity of the underlying silicon by varying the potential of the metal.	Used in digital applications.
Microprocessor	Formerly a microprogrammed central processing unit. More recently, a central processing unit (micro-programmed or not) characterized by low cost through implementation with one or a few LSI integrated circuits.	Used for a number of function such as ignition control in autonomobiles, or as the processing unit in a microcomputer, and is used for fabricating microprocessors and memories, etc.

TERM	DEFINITION	PRINCIPAL USE/FUNCTION
Medium-Scale Integration (MSI)	Medium Scale Integration includes that area of complexity less than LSI, but considerably more than the simple electronic functions.	
NMOS	N-channel MOS, a variation of MOS (see MOS), the dominant technology applied to the fabrication of digital devices.	The technology is estimated to presently account for around 25% of world wide integrated circuit consumption.
Photolithography	The technology of using photosensitive films for masking, patterning and thus controlling integrated circuit processing techniques.	Used for fabricating wafers through the use of masks.
Reliability	The ability of an item to perform a required function under a given condition for a stated period of time.	A term used to define product quality, particularly its ability to withstand extreme environmental conditions such as high temperatures and vibrations.
RAM	Random Access Memory - Memory that may have date written into or read out of any address.	Used in computers and other applications requiring ready retrieval of stored data.
Semiconductors	Solid-State devices with desirable electrical properties. Semiconductors can either be single discrete devices such as transistors and capacitors or integrated circuits (ICs) which combine several devices on a single silicon chip.	Following the invention of the transistor (the first significant solid-state device) in 1947, these have rapidly replaced vacuum tubes and other conventional electrical devices.
Silicon Dioxide (SiO_2)	Glass passivating layer grown at high temperatures by combining oxygen and silicon.	Used in wafer fabrication.
Substrate	A substrate is the starting material into or on which circuit components are placed.	Another term used to describe the base on which ICs are fabricated.
Wafer	A single slice cut from a silicon ingot forming a thin substrate, usually 75-100 mm in diameter, and 0.25-0.30 mm thick.	A completed wafer normally contains hundreds of individual ICs.
Yield	Yield is the ratio of the number of acceptable units to the maximum number possible.	Used in the industry to describe the ratio of functioning or "good" chips in a wafer to the total number of chips possible. It is the most dominant factor in determining technological capability and cost competitiveness.

TECHNICAL ABBREVIATIONS AND ACRONYMS

IC	Integrated Circuit
LSI	Large-Scale Integration
MOS	Metal-Oxide-Silicon
MSI	Medium-Scale Integration
NMOS	N-Channel Metal-Oxide-Silicon
PCB	Printed Circuit Board
RD&E	Research, Development, and Engineering
SSI	Small-Scale Integration
VLSI	Very Large Scale Integration
TV	Television

Industrial Projects Department
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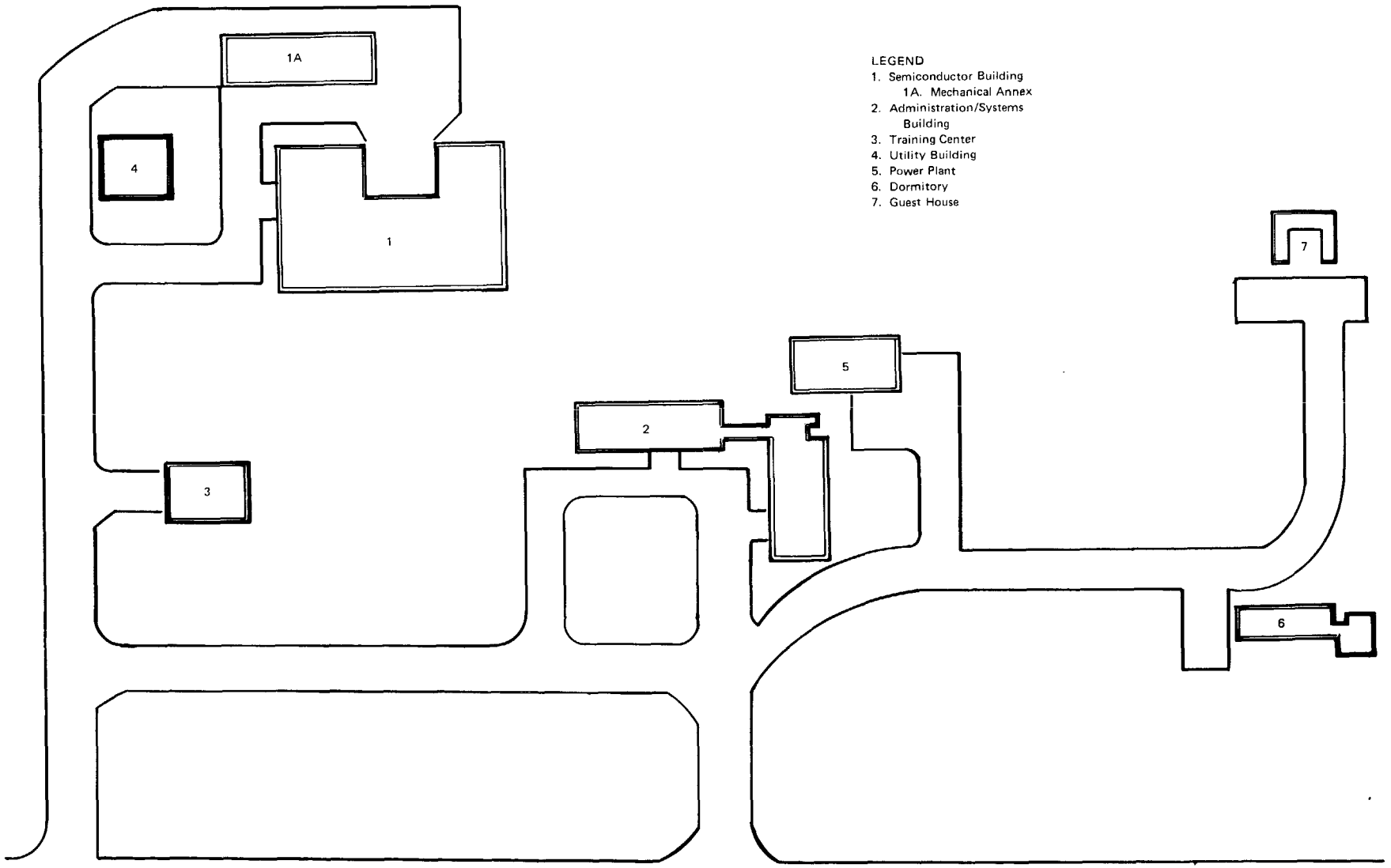
KOREA
ELECTRONICS TECHNOLOGY PROJECT
KIET LAYOUT



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World Bank – 19756

ANNEX 4-1

ANNEX 4-2

KOREA

ELECTRONICS TECHNOLOGY PROJECT

KIET: TECHNOLOGY ACQUISITION ARRANGEMENTS

Activity/Technology	Arrangements/Remarks
Semiconductor Processes Linear Bipolar Process NMOS Process Special Processes	KIET has been thus far focused on recruiting Korean staff with industrial experience in the selected technologies, process training at Hewlett-Packard (US) and some direct purchase of inexpensive proprietary process information. KIET is also investigating training possibilities at the University of Arizona and at Western Digital Corp. (US). Once the KIET facility is operational, one of the major sources of technologies is expected to be "contract manufacturing" agreements with foreign companies who have the selected technologies and are willing to provide them in return for a competitive source of supply. The other major source would be direct purchase agreements, which are expected to be available at reasonable cost from a number of sources. Adequate funds for this purpose have been provided under the project.
Design LSI design, MOS product design Mask-layout and digitizing	In this area KIET has tentatively arranged an extensive program at AMI (US) for over 10 KIET staff (for 4 months - 1 year) to train in selected areas. The trainees will be productively engaged in developing product designs and layouts for AMI in this period. AMI also expects these trainees to be of use in servicing the needs of its joint venture in Korea. Similar arrangements in this area are being discussed with Siemens (Germany), Phillips (Netherlands), and Fairchild (US).

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Mask-Making	Training in conventional mask-making technology has already been completed at IMR (US) under the UNDP project. The training in advanced technology is expected to be provided by the vendor of the electron-beam or other selected equipment.
Conventional Technology Electron-beam or other advanced technology	
Testing	Contract testing arrangements, under which KIET would receive testing know-how, have been arranged with RCA (Taiwan and Malaysia). Other such arrangements are expected with foreign firms that maintain assembly operations in Korea, such as Fairchild (US).
Electrical Testing Environmental Testing	
Quality Control and Assurance	As an activity with potentially a significant and wide ranging impact on industry, quality control and assurance know-how (manuals, programs, aids) are expected to be purchased and offered to industry through training programs.
Systems	Training is underway at Fairchild (US) in software and hardware design. Hewlett-Packard (US) has also agreed to train Korean systems and testing engineers. Discussions have been initiated with a number of companies active in the systems area: Phillips (Netherlands), Siemens (Germany), Terradyne, Data General Corp., Digital Equipment Corp., and Fairchild (US).
Software Design Hardware Design	
Double-Sided Printed Circuit Board (PCB) Technology	Contact initiated with Thermatronics (Japan) and DEA (Division of Phillip Hunt Chemicals (US)) as a source of this technology.

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ANNEX 4-3

KOREA

ELECTRONICS TECHNOLOGY PROJECT

KIET: MANPOWER DEVELOPMENT/TRAINING PROGRAM

	1978	1979	1980	1981	1982
MANPOWER DEVELOPMENT					
Semiconductor Processes					
Principal	1	6	6	6	8
Senior	2	7	9	17	21
Junior	9	10	10	15	21
Technicians/Operators	6	12	50	100	154
Sub-total	18	35	75	138	204
Design/Mask/Test					
Principal	1	3	4	6	6
Senior	2	7	10	13	13
Junior	11	19	28	36	36
Technicians/Operators	5	45	67	95	95
Sub-total	19	74	109	150	150
Systems					
Principal	1	5	7	10	10
Senior	2	12	15	18	18
Junior	15	13	17	27	27
Technicians/Operators	4	17	25	30	30
Sub-total	22	47	64	85	85
RD&E					
Principal	-	5	8	10	12
Senior	-	10	17	22	25
Junior	-	15	25	34	39
Technicians/Operators	-	20	33	44	52
Sub-total	-	50	83	110	128
Administration/Support					
Principal	3	5	6	9	10
Senior	4	5	10	14	16
Junior	11	12	18	27	30
Technicians/Operators	22	25	40	60	65
Sub-total	40	47	74	110	121
TOTAL	99	253	405	593	688

TRAINING (Costs in US$'000)	1979 Trainees	1980 Trainees	1981 Trainees	Total Trainees	Total M-M[b]	Total Cost[c]
Overseas						
Semiconductor Processes	7	6	5	18	108	216
Design/Mask/Test	12	10	10	32	192	384
Systems	23	24	23	70	420	840
Quality Control/Assurance	5	7	3	15	90	180
Marketing	1	1	-	2	12	24
Management	2	2	2	6	36	72
Sub-total	50	50	43	143	858	1,716
Local Outside KIET						
Semiconductor Processes	17	15	23	55	291	44
Design/Mask/Test	-	-	-	-	-	-
Systems	18	15	30	63	249	44
General	1	1	1	3	72	12
Sub-total	36	31	54	121	612	100
Attendance at Conferences	Attendees	Attendees	Attendees	Attendees		Cost[c]
Overall KIET	8	9	8	25		50
FOREIGN EXPERT INVITATION	Experts	Experts	Experts	Experts	M-M[b]	Cost[c]
Semiconductor Processes	4	5	4	13	13	104
Design/Mask/Test	6	5	5	16	16	128
Systems	10	16	6	32	32	256
Quality Control/Assurance	1	1	1	3	3	24
Management/Marketing	-	11	6	17	17	136
Technical Advisor	1	1	1	1	20	160
Facilities	1	2	-	3	3	24
Sub-total	23	41	23	85	104	832

a/ Reflects staff clearly identified with RD&E activities; these activities will also rely quite heavily on manpower included in the operating divisions.

b/ M-M: man-months; average overseas training program 6 months; average expert (excluding technical advisor) appointment 1 month.

c/ Cost basis: overseas training US$12,000/6 M-M period; local training cost varies with program; conference attendance US$2,000/attendee; expert cost US$8,000/M-M period.

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KOREA

ELECTRONICS TECHNOLOGY PROJECT

KIET: DEVELOPMENT PROGRAM

Development Activities	Years			
	1979	1980	1981	1982
Product Development				
Linear ICs - Consumer Applications				
Advanced Color TV - IC set				
ICs for Digital Applications				
ICs for Communication Applications				
ICs for Industrial Applications				
Traffic Control System for Seoul				
Intelligent Terminal/Key Entry System				
Peripheral Controllers				
Microcomputer Board Set				
Applications, Operating Software and Compilers				
Process Development				
Linear Bipolar (Consumer Applications)				
NMOS (Digital Applications)				
Process for Telecommunication Applications				
HMOS (Microprocessors, Memory)				
Process for Advanced Memory Applications				
Double-side Printed Circuit Board Production Technology				

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ANNEX 4-5

KOREA

ELECTRONICS TECHNOLOGY PROJECT

RD&E OPERATIONS

I. Introduction

This Annex outlines the objectives and guidelines for KIET's RD&E operations. These will be reviewed from time to time by KIET and the Bank, and may be amended as needed.

2. Purpose of KIET's RD&E Activities

a) To finance research projects for the development of products, processes and systems in the electronics industry.

b) KIET would only finance research costs for work conducted within KIET's facilities; it would not finance costs of research conducted by industry in-house. (The Government plans to establish a Technology Development Corporation to provide funds for such use.)

c) Costs to be financed would include: personnel (including external consultants), purchase of foreign know-how (where such is cheaper than developing in-house), materials, overheads, and equipment. Specialized equipment purchased by KIET could be sold (at fair market value) on completion of the RD&E project for which it was purchased. In most cases, such equipment would be sold to the sponsoring company. If this is to be done, terms of the sale would be specified in advance at the time of signing of the research contract.

d) KIET may finance projects sponsored both by industry, and by itself without an industry sponsor. On KIET sponsored projects, however, there should be broad industry interest in the end result of the project. This will ensure that research work undertaken by KIET is closely tied to industry goals. Research results of KIET-sponsored projects could either be: licensed externally, or used internally by KIET in the production of products for its service activities. KIET-sponsored projects, however, should not exceed 30% of the cost of

the RD&E program in a single year. This percentage may be varied from time to time as agreed between KIET and the Bank. It is expected that the percentage of KIET-sponsored projects will decline over time as industry support for KIET increases with demonstrated results.

3. Financing of RD&E

a) The Bank will cover the foreign exchange costs of selected RD&E projects up to a total of US$5 million (See 5(d)). The Government, local industry, and KIET (from royalties and internal cash flow generation) will cover all local costs, and all foreign costs after Bank funds have been disbursed.

b) In order to ensure that KIET is able to procure required foreign goods and services for research as quickly as possible, the Government will provide an advance to KIET of US$0.5 million in two equal installments (June 30, 1979, and January 1, 1980). These funds would be used to finance the procurement of initial foreign research expenditures, which would then be re-imbursed by the Bank.

c) Bank funds would be disbursed to KIET on submission of suppliers' invoices and evidence that procurement had followed international shopping procedures. Invoices should be submitted to the Bank periodically--e.g. once accumulated invoices to be reimbursed by the Bank total US$0.25 million. For large packages (in excess of US$0.1 million) KIET may request the Bank to make direct payment to suppliers.

d) Government support of RD&E will be obtained through the general funding arrangements by the Government for KIET's operations overall. That is, in the form of annual Government contributions to cover KIET's deficits (i.e. the excess of KIET's annual capital, operating, and RD&E expenditures over its revenues).

e) Industry funding of RD&E is discussed in (6).

4. Management of RD&E

a) An RD&E Review Committees will be formed from KIET's management comprising: the president of KIET, the three operational vice-presidents, the financial director, and the director of project development.

b) The RD&E Review Committee in consultation with KIET's technical advisor will be responsible for: approval of

a four year research program (to be updated and reviewed at least quarterly); approval of individual research projects; approval of royalty arrangements on projects; and periodic review of ongoing research projects with authority to discontinue funding.

c) In carrying out its functions under b) the RD&E Review Committee may request the advice of: foreign consultants, financial advisors, and other qualified personnel as necessary.

d) KIET's three operational vice-presidents will be responsible for management and supervision of RD&E projects in their areas.

e) The director of project development will be responsible for assisting the operational vice-presidents in identifying and developing new projects with industry. In addition, he will be responsible for carrying out the economic/financial analysis of new projects (See 5(c)) submitted to the RD&E review committee.

f) The financial director of KIET will be responsible for disbursement of funds for RD&E, project costing, collection of royalties, and maintaining a proper system of accounts and reporting system to management.

5. Approval of the RD&E Program

a) Before the beginning of each fiscal year, KIET will prepare a proposed RD&E budget for the following four years. This budget will be based on the overall budget for KIET which will identify funds available for research each year--i.e. forecast revenues plus Bank and Government contributions less operating and capital expenditures. The budget will also identify available manpower to carry out RD&E activities each year.

b) On the basis of (a), KIET will, at the same time, prepare a four year research program consisting of a detailed research program for the following year and an indicative program for the three subsequent years. The program will, in particular, highlight a core group of projects (defined as those for which the total budget is in excess of US$250,000 per project) and provide information for each such project on: annual budgets (including sources of funds: the Bank, industry, KIET); annual manpower requirements; identification of industry sponsors, and project justification (See (c) below). For non-core projects, the four year research program will include similar information, but in less detail. Overall, the manpower and funds requirements of the research program should match the availability of these resources identified in (a).

c) Criteria for selection of research projects will include: (i) priority of the project in relation to national economic goals and the development of the semiconductor and systems industries in Korea; (ii) the potential of the project to promote cooperative RD&E efforts among firms in the industry; (iii) the technical capability of the sponsoring firm to absorb and implement the research results and to produce and market a successful product; (iv) technical merits of the project -- likelihood of success, ability of KIET to carry out from a technical standpoint; (v) alternatives sources of technology (make-buy decision); (vi) relevance of the project in relation to KIET's overall direction and thrust; (vii) ability of the project to integrate the work of KIET's three operating departments; (viii) economic/financial merits of the project (including a rate of return analysis); (ix) commercial viability of the end result -- assessment of the market for the project, estimated sales volume; and (x) financial capability of the sponsoring firm to bear its share of research costs and to bring the final product to commercial fruition.

d) The Bank will review and comment on the overall four year research program annually and monitor its implementation on a quarterly basis. The Bank, however, will not necessarily finance all projects in the program, but will select only those projects which best meet the criteria established in (c) and, particularly, those which promote a cooperative effort among firms.

e) For projects involving the use of Bank funds in excess of US$50,000 per project, KIET will submit a research proposal covering the areas mentioned in (c); a project budget; key information from the research contract including: the rights, obligations, and financial contributions of KIET and the industry sponsor; and a written recommendation of the RD&E Review Committee and KIET's technical advisor.

f) In order to ensure maximum impact on industry development, KIET will emphasize sponsoring of small, quick-maturing projects so that its early success can be demonstrated. Except for projects involving a cooperative effort between two or more firms, KIET will not contribute more than US$0.5 million to a single research project without consulting with the Bank. In addition, KIET will not contribute more than US$0.5 million annually to RD&E work of any one company without consulting with the Bank.

6. Sharing of Research Costs by KIET and Industry

a) In order to ensure industry commitment to projects proposed by it, each sponsoring company would be required to finance a reasonable portion of the costs of research performed on its behalf. The percentage of costs to be borne by industry will be decided on a case-by-case basis and will be defined in the research contract for each project. However, in any one year, it is expected that industry would contribute, on average, at least 35% of the cost of industry-sponsored projects in that year. As the success of KIET in carrying out research projects is demonstrated, it is expected that industry would be willing to fund a progressively greater proportion of research costs.

b) For the purpose of (a) research costs include personnel costs (including salaries and benefits), consultant costs, purchase of foreign know-how, direct and indirect overheads on the facilities used by the project, purchase of specialized equipment, materials and all other costs directly related to the project.

c) In addition to cash contributions, industry may contribute its share of research costs in the form of materials and equipment. Cost of materials should be set by invoice value, and equipment by agreed usage rates.

7. Monitoring of the Program and On-going Research Projects

a) In order to control and monitor research work, each project will include a clear statement of objectives, expected results, and a time schedule for achieving such. In addition, a project budget will be prepared. Actual cost data will be recorded for each project separately in order to provide a basis for budgetary cost control (comparison of actual costs versus budget).

b) The RD&E Review Committee, KIET's technical advisor, and other advisors as necessary will review the progress of the four year program and individual research projects on a quarterly basis. It will have the authority to discontinue funding of individual research projects if objectives are not likely to be met on a cost-efficient basis. Prior approval of the Bank will required before funding is discontinued on Bank-financed projects.

c) For each industry-sponsored project, a representative from the sponsoring firm will be assigned to monitor

the progress of the project. The industry monitor will submit quarterly reports on the progress of the project to the RD&E review committee. These will be reviewed by the Bank for Bank-financed projects.

d) If a sponsoring company should fail to perform its obligations under the contract with KIET it will automatically waive all its rights to the results of the research under the project.

e) As part of the quarterly review of ongoing projects, a statement showing actual costs, original budgeted costs, and estimated costs to complete the project will be prepared. For Bank-financed projects, requests for additional funding above 25% of the budgeted amount will require Bank approval.

8. Royalty Mechanisms

a) Royalty rates will be designed to: (i) induce industry to sponsor research projects at KIET; (ii) to spread technology to as wide a spectrum of industry as possible; and (iii) to recover research costs on an overall basis. Therefore, successful projects should return royalties sufficient to recover, in real terms, the costs of both successful and unsuccessful projects (i.e. royalties should recover costs plus inflation).

b) Royalty rates and the period over which royalties will be paid will be negotiated at the time of signing a research contract with the sponsoring company. Arrangements will vary from project to project and may take the following forms: (i) percentage of sales (sales should be defined as either sales of the specific component or the final product of which it will form a part); (ii) unit royalties -- i.e. royalties paid by unit sold; (iii) fixed fees regardless of sales level; (iv) a combination of minimum fees and a royalty based on sales. Royalty rates should reflect industry participation in research project costs -- i.e. if a sponsoring company contributes 50% of research costs, its royalty rate should be lower than if it contributed only 35%.

c) In the research contract between KIET and the sponsoring company, the latter will be given a specified period of time, after completion of the project, in which to elect to use the results of the project. If the sponsoring company elects to use the research results it is liable for royalty payments under the terms of the research contract. If both KIET and the sponsoring company agree the project

is a failure, both parties retain rights (in proportion to their research cost contribution) to the research results if these are ever sold to a third party (the sponsoring company would retain the rights, however, if a royalty is payable regardless of the successful outcome of the project). In the event of a disagreement as to the success of the project, KIET may "buy-out" the sponsoring company at a negotiated price (not to exceed the cost of the sponsoring company's contribution) and may thereafter license the product to another company and collect royalties (payable to KIET) thereon. Alternatively, after "buy-out", the research result may be used internally by KIET for development of products by it.

d) Research contracts may grant the sponsoring company an exclusive or non-exclusive license at the company's option. Royalty rates for exclusive licenses should be higher than those for non-exclusive licenses. On an exclusive license, the sponsoring company may sub-license the research results to a third party (or parties). KIET will have the right to approve such sub-licensing arrangements, and if its royalty income from the original license is likely to be materially reduced, KIET may renegotiate the original royalty arrangement and/or share in the royalties with the sub-licensees.

9. Special Treatment of Small and Medium-Sized Companies

a) A firm operating policy of KIET will be to encourage technological development of small and medium-sized companies.

b) In order to achieve (a), KIET will use its best efforts to support research projects sponsored by small and medium-sized firms. KIET will endeavor to allocate at least 25% of its annual RD&E funds to such companies.

c) In addition, since small firms are unlikely to have the same financial resources or risk capital of larger enterprises to support research projects, a more liveral research cost sharing arrangement for small companies would be allowed. Therefore, for the purposes of section 6 of this Annex, small firms might contribute a smaller percentage of research costs -- this might be combined with a somewhat higher royalty rate. Alternatively, all or part of the research cost contribution by small firms could be deferred until project completion.

d) For the purposes of this section, small- and medium-sized firms would be defined in the same manner as that under appropriate existing regulations (e.g. tax laws, commercial code, etc.).

10. Reporting Requirements to the Bank on RD&E Operations

a) before the beginning of each year, KIET will prepare a four year research program and a budget for carrying out the proposed program for Bank review and comment.

b) KIET will also submit quarterly reports to the Bank outlining the progress of implementation of the program (and any changes thereto) in the quarter. These reports will include: (i) a brief evaluation of the outcome of research projects completed in the quarter; (ii) a summary of the progress of ongoing projects; and (iii) an outline of new projects approved.

c) Quarterly financial reports will also be required for the RD&E program including: (i) a statement showing actual costs for the year to date compared to the budget; and (ii) a statement of estimated costs to complete the program compared to budget.

d) For Bank-financed projects, the data required in (c) should be provided on a project-by-project basis.

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February 1979

KOREA
ELECTRONICS TECHNOLOGY PROJECT
PROJECT COST ESTIMATE
(US$ 000s)

	1977			1978			1979			1980			1981			Total		
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total
Development of KIET																		
Civil Works																		
Land	-	-	-	136		136	243		243	253		253	825		825	1,457		1,457
Site Preparation	-	-	-	167		167	323	70	393	33		33	-		-	523	70	593
Semiconductor Building	-	-	-	617		617	1,819	600	2,419	-		-	-		-	2,436	600	3,036
Systems/Admin. Building	-	-	-	189		189	210	50	260	688	250	938	-		-	1,087	300	1,387
Training Center	-	-	-	-		-	-		-	706	160	866	-		-	706	160	866
Apartments	-	-	-	-		-	613	100	713	605	440	1,045	-		-	1,218	540	1,758
Dormitories	-	-	-	142		142	128	60	188	-		-	-		-	270	60	330
Guest House	-	-	-	-		-	-		-	177	50	227	-		-	177	50	227
Utility Building	-	-	-	-		-	229		229	-		-	-		-	229	-	229
Power Plant	-	-	-	170		170	-		-	-		-	-		-	170	-	170
Design etc.	56	56	126			126	89		89	107		107	-		-	378	-	378
Sub-total	56	56	1,547			1,547	3,654	880	4,534	2,569	900	3,469	825		825	8,651	1,780	10,431
Support Systems																		
Furnishings	51	51	134	-	134	159	40	199	198	160	358	272		272	814	200	1,014	
General Utilities	-	-	-	-	-	833	220	1,053	5		5	-		-	838	220	1,058	
Semiconductor Support	-	-	-	300	300	-	2,279	2,279	-		-	-		-	-	2,579	2,579	
Systems Support	-	-	-	-	-	-	500	500	-		-	-		-	-	500	500	
Process Utilities	-	-	-	-	-	-	1,864	1,864	-		-	-		-	-	1,864	1,864	
Sub-total	51	51	134	300	434	992	4,903	5,895	203	160	363	272		272	1,652	5,363	7,015	
Equipment																		
Semiconductor Process							1,505	1,505		1,713	1,713			-	-	3,218	3,218	
Mask/CAD/Test							2,138	2,138		1,975	1,975			-	-	4,113	4,113	
Systems							1,552	1,552		810	810			-	-	2,362	2,362	
Advanced Equipment							-	-		-	-		2,000	2,000	-	2,000	2,000	
Books/Journals							-	-		-	-		-	-	-	-	-	
Sub-total							5,095	5,095		4,598	4,598		2,000	2,000		11,693	11,693	
Erection and Installation						503		503	250		250	100		100	853		853	
Duties and Taxes						200		200	100		100	41		41	341		341	
Sub-total						703		703	350		350	141		141	1,194		1,194	
Technology																		
Training				150	150	30	616	646	30	618	648	40	532	572	100	1,916	2,016	
Books, Journals				-	-	-	70	70	-	50	50	-	30	30	-	150	150	
Expert Invitation				150	150	60	180	240	96	288	384	52	156	208	208	774	982	
Technology Acquisition				100	100	-	500	500	-	835	835	-	225	225	-	1,660	1,660	
Sub-total				400	400	90	1,366	1,456	126	1,791	1,917	92	943	1,035	308	4,500	4,808	
Base Cost for Development of KIET	107		107	1,681	700	2,381	5,439	12,244	17,683	3,248	7,449	10,697	1,330	2,943	4,272	11,805	23,336	35,141
Contingencies																		
Physical Contingency							268	1,204	1,472	339	707	1,046	9	289	298	616	2,200	2,816
Allowance for Price Escalation							187	702	889	922	703	1,625	19	476	495	1,128	1,881	3,009
Sub-total							455	1,906	2,361	1,261	1,410	2,671	28	765	793	1,744	4,081	5,825
Total	107		107	1,681	700	2,381	5,894	14,150	20,044	4,509	8,859	13,368	1,357	3,708	5,065	13,549	27,417	40,966
Working Capital[a/]							394	23	417	1,538	272	1,810	3,954	697	4,651	5,886	992	6,878
Total Cost for Development of KIET	107		107	1,681	700	2,381	6,288	14,173	20,461	6,047	9,131	15,178	5,311	4,405	9,716	19,435	28,409	47,844
RD&E Program[a/]																		
Equipment							-	-	-	-	200	200	-	700	700	-	900	900
Training/Technology							-	250	250	-	400	400	-	1,400	1,400	-	2,050	2,050
Materials							-	250	250	-	400	400	-	1,400	1,400	-	2,050	2,050
Labor and Overheads							1,000	-	1,000	2,000	-	2,000	7,000	-	7,000	10,000	-	10,000
Sub-Total Cost of RD&E Program							1,000	500	1,500	2,000	1,000	3,000	7,000	3,500	10,500	10,000	5,000	15,000
TOTAL PROJECT COST	107		107	1,681	700	2,381	7,288	14,673	21,961	8,047	10,131	18,178	12,311	7,905	20,216	29,435	33,409	62,844

a/ Working Capital and RD&E program costs for 1982 (US$2.2 and 6.0 million respectively) are shown jointly with costs for 1981 (US$2.4 and 4.5 million respectively).

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ANNEX 5-2

KOREA

ELECTRONICS TECHNOLOGY PROJECT

ALLOCATION OF BANK FUNDS
(US$ Millions)

Category	Foreign Exchange Amount
Process Support Systems	4.9
Equipment and Spares	
Semiconductor Processes	3.5
Design/Mask/Test	4.5
Systems	2.5
Advanced Equipment	2.3
Total Equipment	12.8
Training and Technology	
Training[a/]	2.0
Expert Invitation	0.7
Technology Acquisition	1.7
Total Training and Technology	4.4
RD & E Program	5.0
Unallocated (Contingencies[b/])	1.9
Total	29.0

a/ includes US$0.1 million for foreign exchange for books and journals.
b/ Physical contingencies only; price contingencies have been included in the relevant categories.

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ANNEX 5-3

KOREA

ELECTRONICS TECHNOLOGY PROJECT

ESTIMATED DISBURSEMENT SCHEDULE
(US$ Millions)

Calendar Year	and Quarter	Bank Fiscal Year	and Quarter	Disbursement	Cumulative Disbursement
1979	III	1980	I	1.0	1.0
	IV		II	12.3	13.3
1980	I		III	4.0	17.3
	II		IV	0.7	18.0
	III	1981	I	1.3	19.3
	IV		II	2.6	21.9
1981	I		III	0.7	22.6
	II		IV	0.7	23.3
	III	1982	I	1.3	24.6
	IV		II	2.4	27.0
1982	I		III	0.8	27.8
	II		IV	0.5	28.3
	III	1983	I	0.4	28.7
	IV		II	0.3	29.0

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KOREA

ELECTRONICS TECHNOLOGY PROJECT

BASIS FOR REVENUE PROJECTIONS

A. Overall Service Revenues

1. In the 1982 steady state, 90% of KIET's service revenues will derive from the provision of: wafers (66%) masks (5%), IC designs (5%), testing (6%), and systems contract work (8%). 1/ The local requirements for these services which provide the basis for the revenue projections are discussed in detail in this annex. A summary table showing KIET's projected service revenues, 1979-82, is given below:

KIET: Projected Service Revenues
(US$000's)

	1979		1980		1981		1982	
	Amount	%	Amount	%	Amount	%	Amount	%
Principal Services								
Wafers	-	-	3,450	47	8,700	56	15,300	66
Masks	140	12	680	9	950	6	1,200	5
IC Design	100	9	425	6	1,135	7	1,250	5
Testing	100	9	640	9	1,190	8	1,300	6
Systems Contracts	700	61	1,155	16	1,695	11	1,865	8
	1,040	91	6,350	87	13,670	88	20,915	90
Ancillary Services								
Printed Circuit Boards	-	-	165	2	655	4	720	3
Peripheral Controllers	50	4	210	3	350	2	385	2
Utilities (H2 Gas)	-	-	330	5	570	4	630	3
Education & Other Services	50	5	230	3	375	2	410	2
	100	9	935	13	1,950	12	2,145	10
Total Service Revenues	1,140	100	7,285	100	15,620	100	23,060	100

1/ On a value added basis, the importance of water services, which include a relatively high proportion of material costs, would be somewhat less than that indicated by the revenue figures.

B. Wafers

2. Demand for wafers is directly related to semiconductor production, the industry rule of thumb being that one wafer is required for every US$200 in semiconductor production. Moreover, demand for semiconductors is expected to increase faster than that of the electronics industry overall. This is so because of the increasing semiconductor content of existing electronics products and the progressive introduction of new electronics products based on continuing developments in semiconductor technology.

3. For the purpose of analysis, it is assumed that Korean electronics production will increase from US$1.8 billion in 1977 to US$4.7 billion in 1982. This is somewhat below the Fourth Five Year Plan target under which the US$4.7 billion figure would be reached in 1981. At the same time, the semiconductor content of Korean electronics is expected to increase from 4% in 1977 to 7% in 1982 (about the level attained in the U.S. industry in 1977). This would result in domestic demand for semiconductors in 1982 of US$334 million, which translates into a requirement for about 1.7 million wafers. Based on present use patterns, this requirement is expected to be divided among the various types of semiconductor devices as follows: discretes (40%), bipolar (20%), NMOS (20%), and other processes (20%).

4. At present, there are two companies in Korea engaged in the manufacture of wafers--Samsung Semiconductor and Toshiba Electric, with annual capacities of 250,000 and 100,000 wafers respectively. Two other companies (Golstar and Taihan Electric) are, however, planning wafer fabrication facilities with the capacity to produce 100,000 wafers annually each, such plants to be on stream by 1980. A number of other companies are in the process of making plans in this area, and it is likely that additional operational capacity of 300,000 wafers annually could be in place by 1982. On this basis, industry production in that year would amount to 850,000 units. Most of this production will be geared to providing wafers for discrete devices and the simpler forms of bipolar and NMOS technology. KIET will service industry requirements for the more complex bipolar and NMOS devices with its planned output of 200,000 wafers annually by 1982. About 70% of this would represent process and product development on products that will be transferred to industry once yields have been built up to acceptable levels. As industry develops its own process and engineering capabilities, the percentage of KIET's wafer services in this area is expected to decline to around 40 to 50% by 1987. The remainder of KIET's wafer supply will be directed to smaller firms which cannot obtain their relatively small requirements at competitive prices elsewhere. The overall demand/supply projections for wafers in Korea is illustrated in the following table:

Demand/Supply for Wafers in Korea

Demand	1977	1978	1979	1980	1981	1982	1985
Korean Electronics Production (US$ Millions) a/ b/	1,758	2,300	2,760	3,312	3,974	4,769	8,241
Semiconductor Content (US$ Millions) a/	70	106	144	192	254	334	725
(Percentage)	(4.0%)	(4.6%)	(5.2%)	(5.8%)	(6.4%)	(7.0%)	(8.8%)
Wafer Requirement if all Semiconductors Mfd. Locally (000's Wafers) c/	350	530	720	960	1,270	1,670	3,625
Supply							
Local Wafer Production ('000 Wafers)	80	200	300	510	775	1,050	2,300
KIET Production Included Above (000's Wafers) c/	-	-	-	60	125	200	200
KIET as a % of Local Production	-	-	-	12%	16%	19%	9%

a/ 1977 figures from MCI: Fine Instruments Centre.

b/ Projections for electronics production based on 30% growth in 1978, and 20% annually thereafter.

c/ Calculated based on the assumption that one wafer is required for every US$200 in semiconductor production.

5. In addition to servicing local industry's requirements, KIET has the capability to service the foreign-owned semiconductor assembly plants located in Korea, which in 1977 assembled and exported US$316 million in semiconductor devices, the wafers for such (about 1.5 million) being imported from parent company plants offshore. Further, a small amount of wafer exports could arise, where as a source of technology, KIET enters into contract production arrangements with foreign firms. In light of the uncertainty of these additional revenue sources, and the large domestic requirements for KIET's wafer services, potential service revenues in these areas have not been included in the projections.

C. Masks

6. The local requirement for masks is directly tied to the volume of wafer production--one mask is required for every two wafers produced. In 1979, KIET will produce a small number of masks from the existing equipment at the KIST semiconductor facility. Once the Gumi plant becomes operational in 1980, however, KIET is expected to become the central source of masks for domestic wafer manufacturers, providing most of their requirements in this area. This is illustrated in the following table:

Mask Requirements
(in 000's)

	1977	1978	1979	1980	1981	1982
Local Wafer Production	80	200	300	510	775	1,050
Masks Required	40	100	150	255	387	525
Projected KIET Mask Production	-	-	35	200	300	400
Internal Consumption of Masks by KIET's Water Fabrication Facility	-	-	-	30	62	100
Masks Supplied by KIET to Local Industry	-	-	35	170	238	300

D. IC Design

7. In terms of trained staff and specialized equipment, KIET will have the only capability in Korea to carry out IC design work. Accordingly, it can be expected to carry out a major share of local industry's requirements in this area. A portion, however, involving particularly complex circuits, will still be provided by overseas firms with specialized expertise.

8. Industry design work requirements are directly related to the forecast for local semiconductor production, with approximately one design required for each US$3 million in device sales. Each design can be expected to have an average product life of about 3 years. Therefore one design will be needed for each US$1 million in annual semiconductor production. Using the table in para. 4 as a base, results in the design requirements, 1977-82, shown in the table below. Overall, it is expected that KIET will be able to produce about 75 designs per year by 1981, which would represent about half of the design requirements for semiconductors produced in Korea in that year.

IC Design Requirements

	1977	1978	1979	1980	1981	1982
Local Semiconductor Production (US$ Million) a/	16	40	60	102	155	210
No. of Designs Required	16	40	60	102	155	210
No. of Designs Provided by KIET	-	-	8	31	75	75

a/ From the table in para 4. One wafer generates US$200 in finished semiconductor devices.

E. Testing

9. At present, there is no local facility for carrying out electrical and environmental testing of semiconductor devices and systems hardware. These services must thus be obtained abroad, at considerable expense, or omitted entirely with consequent implications for quality control. KIET's testing facility will thus, in the short-term, be the sole source of testing services for local semiconductor manufacturers. Since testing fees run between 4 and 5% of the price of the finished device, the local market for these services can be defined as follows:

Testing Requirements

	1977	1978	1979	1980	1981	1982
Local Semiconductor Production (US$000's)	16,000	30,000	40,000	820,000	125,000	170,000
Testing Requirements (4% of above)	640	1,200	1,600	3,280	5,000	6,800
Testing Performed by KIET (US$000's)	-	-	100	640	1,190	1,300

10. Over the longer term, it is expected that local semiconductor manufacturers will develop their own in-house testing capabilities, although in light of the large annual testing requirements involved, KIET's services will still be required in this area. In addition, KIET also has the potential to provide testing services to the foreign semiconductor assembly houses based in Korea which, with a 1977 output of US$316 million, have testing requirements in excess of US$12 million annually, all of which are now provided from abroad.

F. Contract Systems Work

11. KIET, with its pool of trained scientists, engineers and technicians, will have substantial capability for the design and development of a wide range of microprocessors, minicomputers, and other digital systems for use in Korea. At present, KIET in partnership with the Korean firm, Oriental Precision Co. (OPC), is negotiating a contract with the city of Seoul for development of a traffic control system. KIET's share of the contract, which would split the software and hardware components between KIET and OPC respectively, would amount to about US$700,000 for work to be performed in 1979. Over the longer term, if the present project is a success, KIET could develop traffic control systems for other cities and further potential exists in a vast array of computerized systems work for government, business, hospitals, schools, and other institutions. For projection purposes, it is assumed that by 1981, KIET will be handling two projects a year comparable in size to the traffic system.

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KOREA

ELECTRONICS TECHNOLOGY PROJECT

ASSUMPTIONS FOR FINANCIAL PROJECTIONS

A. Income Statement: Service Operations

1. Service Revenues: These are based on the assessment of local requirements presented in Annex 6-1. Projected volumes in each major service area are as follows:

KIET: Service Volumes
(Units)

Wafers	1979	1980	1981	1982
3" Wafers	-	60,000	85,000	100,000
4" Wafers	-	-	40,000	100,000
	-	60,000	125,000	200,000
Masks				
Total Production	35,000	200,000	300,000	400,000
Less: Used Internally by KIET a/	-	30,000	62,500	100,000
Supplied to Industry	35,000	170,000	237,500	300,000
IC Design				
No. of Designs	8	31	75	75
Testing				
Value in US$000 b/	100	640	1,190	1,300
Systems Contract Work				
No. of Contracts	1.0	1.5	2.0	2.0

a/ One mask is required for every two wafers produced.

b/ Based on detailed calculations of volumes and prices for the various types of semiconductor devices to be tested.

2. In view of the competitive nature of the electronics industry worldwide, the prices for KIET's services are expected to be set at levels equal to those for similar services in the U.S. industry so as not to place at a disadvantage the Korean industry which is still at a very early stage of development. At the same time, KIET will, to the extent consistent with its role as an organizations designed to stimulate development of the electronics industry, recover through its prices the cost of carrying out its service operations, including a notional interest charge of 10% on that portion of Bank funds being provided for such services. A statement of KIET's service pricing policy is contained in Annex 6-3.

3. Prices for wafers and masks are forecast to remain constant (in current terms), 1979-82, reflecting the normal learning experience in the industry where improved manufacturing technology has allowed semiconductor firms to maintain production costs and prices at fairly constant levels from year to year. Beyond 1982, it is assumed that increasing product complexity will result in an increase in mask and wafer prices of 10% annually. For IC design, testing, and systems contract work, where the bulk of costs are labor, prices are projected to increase by 10% annually over the 1979-87 forecast period. Assumed prices for services in the base year, 1979, are shown below:

	Assumed Prices for Services Per Unit (current US$)			
Wafers				
	1979	1980	1981	1982
3" Wafers	-	55	55	55
4" Wafers	-	-	95	95
Masks	4	4	4	4
IC Design	12,500	13,750	15,125	16,638
Systems Contract Work	700,000	770,000	847,000	932,000

4. Labor: Manpower requirements are based on a detailed analysis of direct labor inputs required in each service area. The manpower plan for KIET overall, 1979-82, is given in Annex 4-3. Labor costs are based on KIET's actual 1978 wage and salary levels including fringe benefits and annual bonuses (normally four months salary). Compensation is assumed to increase by 20% annually in 1979 and 1980, 15% annually in 1981 and 1982, and 10% annually thereafter. This is shown in the table below:

Average Annual Salaries and Wages
(current US$000's)

	1979	1980	1981	1982
Principals	21.5	25.8	29.7	34.2
Seniors	15.1	18.1	20.8	23.9
Juniors	9.1	10.9	12.5	14.4
Technicians	5.6	6.8	7.8	9.0
Operators	4.0	4.8	5.5	6.3

5. Materials: Material costs are based on international prices for imported materials plus costs of delivery to Korea (KIET is exempt from customs duties) and local prices for domestic materials. A detailed analysis of the required material inputs in each service area has been conducted, resulting in the average material costs per unit, 1979-82, given below. Beyond 1982, all material costs are assumed to inflate by 10% annually.

Material Costs Per Unit
(current US$000's)

	1979	1980	1981	1982
Wafers a/ b/ c/				
3" Wafers	-	18.22	18.22	18.22
4" Wafers	-	-	32.78	25.33
Masks b/	1.34	1.34	1.34	1.34
IC Design	---------- No material costs ----------			
Testing	---------- 10% of sales ----------			
Systems Contract Work	---------- 20% of sales ----------			

a/ Material costs for wafers exclude the costs of masks. This has been accounted for under the cost of mask services.

b/ 3" wafer and mask material costs per unit are assumed to remain constant, 1979-82, as moderate increases in material costs are absorbed by offsetting improvements in yield.

c/ Material costs for 4" wafers decline sharply in 1982, reflecting major yield improvements once this technology has been assimilated by KIET.

6. Overheads: These consist of miscellaneous operating supplies, fuel oil, water, heat, light, etc. and are forecast at 25% of labor costs each year.

7. Services R&D: This represents the on-going costs to KIET of development improved production processes to enable it to keep pace with the latest process developments in the industry and thereby to maintain its costs at competitive levels. This has been forecast at 5% of annual revenues, which is somewhat lower than the 8-10% of revenues spent by the industry leaders. The difference is explained by lower wage costs in Korea, as well as the fact that KIET will be concentrating in proven products and processes where production research requirements are lower than in less mature products.

8. Power: Power costs in Korea are presently US$0.066 per KWh. This rate is expected to increase by 10% annually over the forecast period, 1979-87. Power consumption by KIET's facilities each year are projected as follows:

	1979	1980	1981	1982
KIET Power Consumption (000's KWh)	3,000	17,000	25,000	30,000

9. Maintenance: Maintenance costs are projected at 4% of annual revenues. This is in line with industry experience internationally.

10. US Liaison Office: US liaison office costs are based on projected US-based staff requirements 1979-82, plus an allowance for overheads of 100% over and above basic salaries. US costs are inflated 7% annually 1979-82.

11. General and Administration: These costs are based on the administrative staff requirements detailed in Annex 4-3, costed at the salary and wage rates given in para 3 of this annex. Other administration costs (travel, insurance, office supplies, transportation, communication, entertainment, etc.) are projected at 100% of annual administrative salaries and wages. This is in line with KIET's experience for these costs in 1977 and 1978.

12. Training, Technology Acquisition, and Expert Invitation: Costs in this area, 1979-81, are considered part of KIET's cost of start-up and are included in the project cost table in Annex 5-1. For income calculation purposes, they are treated as a deferred expense and amortized over five years as described in para 13 below. Costs in 1982 are projected at US$1 million (80% of their 1981 level), and inflated 10% annually thereafter.

13. Depreciation and Amortization: These have been calculated on a straight-line basis using the average of beginning and end of year amounts in each asset category. Rates used are as follows: buildings (5%); equipment

(10%); and deferred expenses (20%). Depreciation and amortization is charged for six months in 1979 to reflect the fact that facilities in that year will only be partially utilized.

14. Indirect Expenses Charged to RD&E: A portion of KIET's overheads representing: depreciation and amortization, general and administrative costs, power and maintenance charges on facilities which are shared by both service and RD&E operations have been allocated to RD&E. This allocation is necessary in order to properly reflect income from service operations and to account for RD&E project costs for the purpose of calculating industry's contribution (para 21) as well as royalties to recover KIET's share of RD&E costs. In order to be conservative, however, overheads charged to RD&E are limited to 75% of annual RD&E manpower costs. This percentage is in line with the practice used by other Korean research institutes, such as KIST, to allocate overhead costs to contract research carried out by it for industry. It is unlikely that KIET, therefore, will be able to pass overheads onto industry in excess of this percentage, even though a greater charge might be warranted on the basis of the resources devoted to RD&E each year.

15. Interest Income: Interest income has been calculated at 15% of year-end cash balances. This is reasonable in light of current interest rates in Korea which are in excess of 20% annually for bank deposit accounts.

16. Income Taxes: As a Government institute KIET is not liable for income taxes.

B. Sources and Application of Funds: RD&E Operations

17. Royalties: Royalties from successful RD&E projects are expected to be set at a sufficient level to enable KIET to recover the costs of both its successful and unsuccessful RD&E work. For the purpose of analysis, it is assumed that one half of the projects undertaken by KEIT will be successful. This will mean that royalties on successful projects will amount to twice their cost. Because of low labor and engineering costs in Korea, such royalty charges would still be competitive when compared to the cost of purchasing technology directly from offshore sources. For projections purposes, royalties are calculated in equal installments over five years to return to KIET its net RD&E costs in each year plus an allowance for inflation of 10% annually over the forecast period, 1979-87.

18. Sale of Equipment: After completion of RD&E projects, specialized equipment purchased for such is assumed to be transferred to industry.

19. RD&E Expenses: Annual RD&E expenses (manpower, materials, equipment, training and technology purchase, and overheads) are based on cost estimates for representative RD&E projects which KIET is likely to undertake over the 1979-82 period. Research expenditures are expected to increase from US$1.5 million in 1979 to US$6.0 million in 1982. Thereafter, RD&E expenditures are forecast to increase, in real terms, by 10% annually. In current terms, this

results in an increase of 21% annually. By 1987, total RD&E expenditures are projected to reach US$15.5 million representing about 40% of KIET's total activities in that year.

20. Financing of RD&E Expenditures: KIET will bear 100% of the cost of RD&E projects sponsored solely by it (assumed to be 30% of the total). On industry sponsored projects (70% of the total), cost sharing between KIET and industry is expected to be done on a 65:35 basis respectvely. Provision of Bank funds for RD&E is based on the foreign exchange costs of annual RD&E expenditures (materials, equipment, and training and technology purchase) until the US$5 million allocated for this purpose is expended in 1982. Government financing will also be required to meet deficits on RD&E operations until cash generation from KIET's service operations is sufficient to cover these. This is expected to occur in 1982.

C. Balance Sheets

21. Working Capital: Assumptions used in the calculation of working capital are as follows:

Cash: 15 days' service revenues; plus one month's total direct RD&E expenditures

Accounts Receivable: Two months' service and royalty revenues

Other Receivables: two months' industry contributions to RD&E costs plus two months' revenues from the sale of equipment

Raw Materials Inventory: three months' material costs.

Work in Process and Finished Goods: one month's direct cost of services, including power and maintenance costs.

Other Current Assets: 1% of service revenues plus direct RD&E expenditures.

Accounts Payable: two months' direct cost of services, general and administrative costs, power, and maintenance less labor costs in these areas; plus two months' direct RD&E expenditures less labor and indirect overhead costs.

Other Current Liabilities: 2% of service revenues plus direct RD&E expenditures.

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ANNEX 6-3

KOREA

ELECTRONICS TECHNOLOGY PROJECT

KIET: SERVICE PRICING POLICY

1. Introduction

This Annex outlines the policy and principles for establishing prices for the services to be provided by KIET. The services covered herein include: design of integrated circuits and systems; supply of wafers, masks, and special gases, testing of components and systems; and equipment maintenance services where such are not undertaken as part of an RD&E effort. The policy and principles will be reviewed from time to time by KIET and may be amended as needed in consultation with the Bank.

2. Policy and Principles

In pricing its service operations, KIET will take into account its primary role as an organization designed to stimulate the development of the electronics industry in Korea, while recognizing the desirability, to the extent consistent with this objective, of recovering the cost of carrying out these service operations and generate from December 30, 1983 onwards funds sufficient to cover both its cash deficit from its RD&E operations and the funds required to maintain and develop its technological capabilities consistent with the industry's needs. For the purpose of costing KIET's services, a notional interest of 10% will be applied to the portion of World Bank funds used in providing such services.

In providing services, KIET will emphasize the diffusion of know-how aimed at building the technological capabilities of a broad segment of the Korean electronics industry. Given the present stage of development of Korean industry, KIET will thus undertake as part of its service function the education and training of industry personnel, which has proved to be an effective method of technology transfer. Further, it will provide a continuously advancing mix of services leading the pace of industry's development. In many instances, KIET will provide specific services in low volumes for short periods of time and be unable to take full advantage of learning curve and volume efficiencies. In view of this development and technological pacesetting role, KIET's cost of providing the services may be higher than for an organization providing such services on a purely commercial basis. In setting prices in such cases, KIET will balance its objective of cost recovery against the likely impact of the electronics industry worldwide, the prices for KIET's services are expected to be set in line with prices for such services elsewhere so as not to place at a disadvantage an industry which is still at a very early stage of development. This is not only important to attract domestic and joint venture investment in this sector but also vital for the small and medium sized firms which will have to rely on KIET for the bulk of their basic technological and technical needs.

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KOREA

ELECTRONICS TECHNOLOGY PROJECT

PROJECTED INCOME STATEMENTS (SERVICES)

(IN MILLION WON)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
TOTAL SERVICE REVENUES	-	92	554	3,533	7,575	11,185	12,303	13,534	14,887	16,374	18,006
DIRECT COST OF SERVICES											
LABOR	-	20	469	1,000	1,643	2,105	2,317	2,547	2,803	3,081	3,391
MATERIALS	-	41	120	871	1,958	2,787	3,066	3,373	3,709	4,080	4,486
OVERHEADS	-	20	116	251	410	528	580	637	702	772	848
DIRECT COST OF SERVICES	-	81	705	2,122	4,011	5,420	5,963	6,557	7,214	7,933	8,725
GROSS PROFIT	-	11	(151)	1,411	3,564	5,765	6,340	6,977	7,673	8,441	9,281
INDIRECT EXPENSES											
PRODUCTION R&D	-	-	28	177	379	559	615	677	744	819	900
POWER	-	-	97	603	976	1,287	1,415	1,557	1,713	1,884	2,072
MAINTENANCE	-	-	22	141	303	447	492	541	595	655	720
U.S LIASON OFFICE	-	19	97	182	261	279	307	337	371	408	449
GENERAL & ADMIN.	186	483	412	689	1,174	1,567	1,723	1,896	2,085	2,293	2,522
TRAINING & TECH. ACQUISITION	-	-	-	-	-	485	534	587	646	710	781
DEPRECIATION & AMORTIZATION	3	12	279	1,335	1,785	1,919	1,919	1,992	1,852	1,787	1,972
TOTAL INDIRECT EXPENSES	189	514	935	3,127	4,878	6,543	7,005	7,587	8,006	8,556	9,416
INDIREC EXP. CHARGED TO RD&E	-	-	182	364	546	728	880	1,065	1,288	1,559	1,886
NET INDIRECT EXPENSES	189	514	753	2,763	4,332	5,815	6,125	6,522	6,718	6,997	7,530
OPERATING INCOME	(189)	(503)	(904)	(1,352)	(768)	(50)	215	455	955	1,444	1,751
INTEREST INC.	26	74	12	39	73	103	118	134	154	176	202
TOTAL INCOME	(163)	(429)	(892)	(1,313)	(695)	53	333	589	1,109	1,620	1,953

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ELECTRONICS TECHNOLOGY PROJECT

PROJECTED SOURCES AND APPLICATIONS OF FUNDS (RD&E)

(IN MILLION WON)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
SOURCES											
R.D.&E OPERATIONS											
ROYALTY REVENUES	-	-	-	121	375	764	1,307	2,001	2,687	3,391	4,161
SALE OF EQUIPMENT	-	-	-	-	49	73	97	118	143	173	209
FUNDS FROM R.D.&E OPERATIONS	-	-	-	121	424	837	1,404	2,119	2,830	3,564	4,370
CONTRIBUTIONS											
ROK GOVT - IBRD	-	-	242	485	728	970	-	-	-	-	-
ROK GOVT - OWN	-	-	326	533	567	-	-	-	-	-	-
TOTAL CONTRIBUTIONS	-	-	568	1,018	1,295	970	-	-	-	-	-
TOTAL SOURCES	-	-	568	1,139	1,719	1,807	1,404	2,119	2,830	3,564	4,370
USES											
RD&E EXPENSES											
MANPOWER	-	-	243	485	728	970	1,174	1,420	1,718	2,079	2,515
MATERIALS	-	-	121	194	291	388	469	568	687	831	1,006
EQUIPMENT	-	-	-	97	146	194	235	284	344	416	503
TRAINING & TECHNOLOGY	-	-	121	194	291	388	469	568	687	831	1,006
DIRECT OVERHEAD	-	-	61	121	182	243	293	355	429	520	629
INDIRECT OVERHEAD	-	-	182	364	546	728	880	1,065	1,288	1,559	1,886
TOTAL RD&E EXPENSES	-	-	728	1,455	2,184	2,911	3,520	4,260	5,153	6,236	7,545
LESS: INDUSTRY PARTICIPATION	-	-	178	356	535	713	862	1,044	1,262	1,528	1,849
NET RD&E EXPENSES	-	-	550	1,099	1,649	2,198	2,658	3,216	3,891	4,708	5,696
INCREASE IN WORKING CAPITAL	-	-	18	40	70	88	110	140	143	150	170
TOTAL USES	-	-	568	1,139	1,719	2,286	2,768	3,356	4,034	4,858	5,866
DEFICIT TO BE COVERED BY SERVICE OPERATIONS		-	-	-	-	(479)	(1,364)	(1,237)	(1,204)	(1,294)	(1,496)

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KOREA

ELECTRONICS TECHNOLOGY PROJECT

PROJECTED SOURCES AND APPLICATIONS OF FUNDS

SERVICE AND RD&E OPERATIONS

(IN MILLION WON)

SOURCES	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
NET INCOME	(163)	(429)	(892)	(1,313)	(695)	53	333	589	1,109	1,620	1,953
DEPRECIATION & AMORT.	3	12	279	1,335	1,785	1,919	1,919	1,992	1,852	1,787	1,972
FUNDS FROM SERVICE OPERATIONS	(160)	(417)	(613)	22	1,090	1,972	2,252	2,581	2,961	3,407	3,925
R.D.&E OPERATIONS											
ROYALTY REVENUES	-	-	-	121	375	764	1,307	2,001	2,687	3,391	4,161
SALE OF EQUIPMENT	-	-	-	-	49	73	97	118	143	173	209
FUNDS FROM R.D.&E OPERATIONS	-	-	-	121	424	837	1,404	2,119	2,830	3,564	4,370
CONTRIBUTIONS											
ROK GOVT - IBRD	-	-	6,445	4,141	2,508	970	-	-	-	-	-
ROK GOVT - OWN	524	1,818	3,402	4,176	1,290	-	-	-	-	-	-
ROK GOVT - FOR DEBT SERVICE [a]	-	-	480	3,150	3,523	4,039	6,907	9,247	8,866	8,485	8,108
INDUSTRY	364	317	-	-	-	-	-	-	-	-	-
TOTAL CONTRIBUTIONS	888	2,135	10,327	11,467	7,321	5,009	6,907	9,247	8,866	8,485	8,108
TOTAL SOURCES	728	1,718	9,714	11,610	8,835	7,818	10,563	13,947	14,657	15,456	16,403
USES											
FIXED ASSETS EXPENDITURES	52	960	8,964	5,421	1,843	-	-	1,455	1,600	1,761	1,936
DEFERRED EXPENDITURES	-	194	758	1,062	615	-	-	-	-	-	-
TOTAL CAPITAL EXPENDITURES	52	1,154	9,722	6,483	2,458	-	-	1,455	1,600	1,761	1,936
RD&E EXPENSES											
MANPOWER	-	-	243	485	728	970	1,174	1,420	1,718	2,079	2,515
MATERIALS	-	-	121	194	291	388	469	568	687	831	1,006
EQUIPMENT	-	-	-	97	146	194	235	284	344	416	503
TRAINING & TECHNOLOGY	-	-	121	194	291	388	469	568	687	831	1,006
DIRECT OVERHEAD	-	-	61	121	182	243	293	355	429	520	629
INDIRECT OVERHEAD	-	-	182	364	546	728	880	1,065	1,288	1,559	1,886
TOTAL RD&E EXPENSES	-	-	728	1,455	2,184	2,911	3,520	4,260	5,153	6,236	7,545
LESS: INDUSTRY PARTICIPATION	-	-	178	356	535	713	862	1,044	1,262	1,528	1,849
NET RD&E EXPENSES	-	-	550	1,099	1,649	2,198	2,658	3,216	3,891	4,708	5,696
DEBT SERVICE [a]	-	-	480	3,150	3,523	4,039	6,907	9,247	8,866	8,485	8,108
INCREASE IN WORKING CAPITAL	676	564	(1,038)	878	1,205	1,049	424	480	520	565	625
TOTAL USES	728	1,718	9,714	11,610	8,835	7,286	9,989	14,398	14,877	15,519	16,365
ADDITIONAL SURPLUS CASH	-	-	-	-	-	532	574	(451)	(220)	(63)	38

[a] DEBT SERVICE OBLIGATIONS ON THE BANK FUNDS ARE BORNE BY THE GOVERNMENT THROUGH ANNUAL BUDGETARY ALLOCATIONS TO KIET

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ANNEX 6-7

KOREA

ELECTRONICS TECHNOLOGY PROJECT

PROJECTED BALANCE SHEETS

(IN MILLION WON)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
ASSETS											
CURRENT ASSETS:											
CASH	664	1,105	67	232	439	629	712	807	917	1,045	1,191
ACCOUNTS RECEIVABLES	-	-	93	610	1,328	1,996	2,273	2,594	2,935	3,300	3,702
OTHER RECEIVABLES	34	177	30	59	98	131	160	194	235	284	344
INVENTORY											
RAW MATERIALS	-	-	30	218	490	697	767	843	927	1,020	1,122
WORK IN PROCESS	-	-	69	239	441	596	656	721	793	872	959
FINISHED GOODS	-	-	69	239	441	596	656	721	793	872	959
TOTAL INVENTORY	-	-	168	696	1,372	1,889	2,079	2,285	2,513	2,764	3,040
OTHER CURRENT ASSETS	12	44	11	46	92	134	149	167	188	211	237
TOTAL CURRENT ASSETS	710	1,326	369	1,643	3,329	4,779	5,373	6,047	6,788	7,604	8,514
SURPLUS CASH	-	-	-	-	-	532	1,106	655	435	372	410
FIXED ASSETS											
GROSS FIXED ASSETS	52	1,012	9,976	15,397	17,240	17,240	17,240	18,695	20,295	22,056	23,992
ACCUMULATED DEPRECIATION	3	15	237	1,276	2,597	3,990	5,383	6,849	8,467	10,254	12,225
NET FIXED ASSETS	49	997	9,739	14,121	14,643	13,250	11,857	11,846	11,828	11,802	11,767
GROSS DEFERRED EXP.	-	194	952	2,014	2,629	2,629	2,629	2,629	2,629	2,629	2,629
ACCUMULATED AMORT.	-	-	57	354	818	1,344	1,870	2,395	2,629	2,629	2,629
NET DEFERRED EXPENSES	-	194	895	1,660	1,811	1,285	759	234	-	-	-
GROSS INVESTMENT IN RD&E	-	-	550	1,649	3,298	5,496	8,154	11,370	15,261	19,969	25,665
LESS RETURN ON INVESTMENT	-	-	-	121	545	1,382	2,786	4,905	7,735	11,299	15,669
NET INVESTMENT IN RD&E	-	-	550	1,528	2,753	4,114	5,368	6,465	7,526	8,670	9,996
TOTAL ASSETS	759	2,517	11,553	18,952	22,536	23,960	24,463	25,247	26,577	28,448	30,687
LIABILITIES AND CAPITAL											
CURRENT LIABILITIES											
ACCOUNTS PAYABLE	3	62	145	470	859	1,177	1,316	1,474	1,655	1,860	2,093
OTHER CURRENT LIABILITIES	31	24	22	93	185	268	299	335	375	421	473
TOTAL CURRENT LIABILITIES	34	86	167	563	1,044	1,445	1,615	1,809	2,030	2,281	2,566
CAPITAL											
CONTRIBUTIONS											
ROK GOVT - IBRD	-	-	6,445	10,586	13,094	14,064	14,064	14,064	14,064	14,064	14,064
ROK GOVT - OWN	524	2,342	5,744	9,920	11,210	11,210	11,210	11,210	11,210	11,210	11,210
INDUSTRY	364	681	681	681	681	681	681	681	681	681	681
TOTAL CONTRIBUTIONS	888	3,023	12,870	21,187	24,985	25,955	25,955	25,955	25,955	25,955	25,955
RETAINED EARNINGS	(163)	(592)	(1,484)	(2,798)	(3,493)	(3,440)	(3,107)	(2,517)	(1,408)	212	2,166
TOTAL CAPITAL	725	2,431	11,386	18,389	21,492	22,515	22,848	23,438	24,547	26,167	28,121
TOTAL LIABILITIES AND CAPITAL	759	2,517	11,553	18,952	22,536	23,960	24,463	25,247	26,577	28,448	30,687

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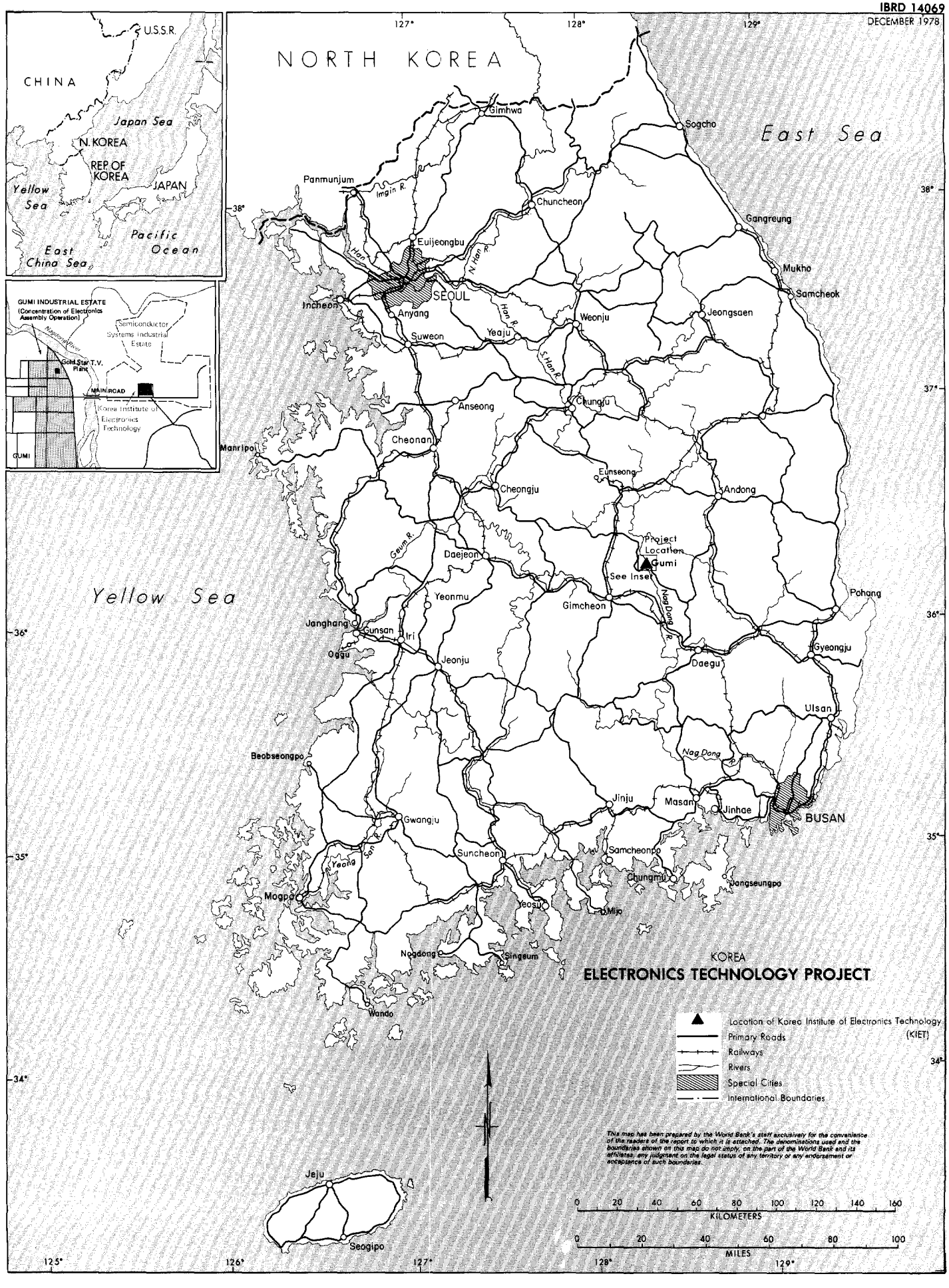

KOREA

ELECTRONICS TECHNOLOGY PROJECT

▲ Location of Korea Institute of Electronics Technology (KIET)
Primary Roads
Railways
Rivers
Special Cities
International Boundaries